ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA

Published by the
ENTOMOLOGICAL SOCIETY OF AMERICA
Formed in 1953 by Consolidation of the
American Association of Economic Entomologists
(1889-1952)
and the former
Entomological Society of America
(1906–1952)

Volume 50 July, 1957 Number 4

ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA

THE ENTOMOLOGICAL SOCIETY OF AMERICA
1530 P Street, N. W.
Washington 5, D. C.

MAURICE T. JAMES, *Editor*
State College of Washington
Pullman, Washington

ROLAND F. HUSSEY, *Associate Editor*
University of Florida,
Gainesville, Florida

EDITORIAL BOARD

L. E. CHADWICK, *Chairman*, Urbana, Ill. (B, 1957)
R. I. SAILER, Washington, D. C. (A, 1958)
M. H. HATCH, Seattle, Wash. (A, 1959)
L. E. ROZEBOOM, Baltimore, Md. (D, 1960)
J. A. ADAMS, Poughkeepsie, N. Y. (C, 1961)

A bimonthly journal published on the 15th of January, March, May, July, September, November, devoted to the interest of classical entomology. Authors are entirely responsible for statements in the *Annals*, whether of fact or opinion.

TERMS OF SUBSCRIPTION. Non-members in North America and U. S. Possessions—$12.00 per year; elsewhere—$12.00 plus 60¢ postage. Single copies $2.25, plus postage of 10¢ per copy. Deliveries overseas are not guaranteed and foreign mailings are made at the subscriber's risk.

LOST NUMBERS. Missing numbers cannot be supplied free of charge unless notice is received within 60 days after the appearance of issues concerned.

BACK NUMBERS are furnished at the following prices: volumes 1 to 31, $4.00 per volume, $1.00 per issue; volumes 32 to 38, $5.00 per volume, $1.25 per issue; volumes 39 to 45, $6.00 per volume, $1.50 per issue; volumes 46 to 48, $10.00 per volume, $2.50 per issue, volume 49, $12.00, $2.25 per issue.

REPRINTS. No gratis copies are supplied. A schedule of prices which will apply to orders received before the Annals is printed, and an order form are sent with proof. For price schedule, see Bulletin of the Entomological Society of America, Vol. 1, No. 4, December, 1955, or page 509 of Vol. 49(5) of the *Annals*.

BUSINESS COMMUNICATIONS of the Society and **SUBSCRIPTIONS AND MATTERS PERTAINING TO ADVERTISEMENTS** should be sent to the Executive Secretary, Entomological Society of America 1530 P Street, N W., Washington 5, D. C. Change of address must reach the office of the Executive Secretary 5 days prior to the month of issue to be effective for that month. Members should make use of the postal regulations which provide for forwarding of second class mail it postage upon delivery is guaranteed.

POSTAL EMPLOYEES send notice on Form 3579 to 1530 P Street, N.W., Washington, D.C

MANUSCRIPTS and other copy for the Annals should be addressed to the Editor. Prompt publication of acceptable matter may be secured by payment of the cost of printing and engraving ($16.00 per page plus cost of engravings with additional charge for excessive tabular matter). Cost of engravings in excess of $15.00, for each eight printed pages or major fraction thereof, will be charged to the author. Before preparing manuscripts for publication in the Annals, authors are urged to consult the Publication Policies and Manuscript Rules and Suggestions given in Vol. 49 (5): 506–9, September 1956.

THE THOMAS SAY FOUNDATION. Five volumes have been published. Send inquiries and orders to Executive Secretary, Entomological Society of America, 1530 P Street, Washington 5, D. C.

Entered as second class matter April 11, 1908, at the Post Office at Columbus, Ohio, under the act of Congress of March 3, 1879. Subject to rate of postage provided for in Paragraph 4, Section 538, P. L. & R., authorized September 16, 1940.

Printed by The Spahr & Glenn Company,
50 East Broad Street
Columbus 15, Ohio, U. S. A.

Issued July 15, 1957

Annals of
The Entomological Society of America

Volume 50 JULY, 1957 No. 4

A CHECKLIST OF THE EPHEMEROPTERA OF NORTH AMERICA NORTH OF MEXICO

GEORGE F. EDMUNDS, JR. AND RICHARD K. ALLEN[1]
University of Utah, Salt Lake City, Utah

The publication in 1935 of "The Biology of Mayflies" by J. G. Needham, J. R. Traver, and Yin-chi Hsu gave considerable impetus to the study of the North American mayfly fauna. The extensive researches on Ephemeroptera during the last twenty years have largely out-dated the checklist provided therein by Dr. Traver's monograph of the North American species. Many additional species have been described and some European species are now known to occur in North America. Some new genera have been described and others added to the known Nearctic fauna. The list of species has been reduced by a number of new synonymies and the placement of some as subspecies of other species. Other changes are a result of the transfer of species from one genus to another, and a rearrangement of higher categories to follow the system proposed by Edmunds and Traver (1954).

A few names have been included in the past in the North American checklist in the hope that they might be eventually correctly applied. In the few cases where we feel that there is no chance of positively applying these names we are indicating them as *nomina dubia*, with the intent of having the names suppressed later as provided for in the Copenhagen decisions of the International Commission of Zoological Nomenclature. Those names which we think can not be applied are *Ephemera noveboracana* Lichtenstein (1796), *Callibaetis hageni* Eaton (1885), *Ephemerella unicornis* Needham (1905), *Cloe quebecensis* Provancher (1876), *Ephemerella consimilis* Walsh (1862), and *Palingenia puella* Pictet (1843), and we declare these *nomina dubia* for the following reasons.

Ephemera noveboracana Lichtenstein was apparently the first mayfly described from North America, but its authorship has been credited to Hagen (1862). Mr. D. E. Kimmins has examined the copy of Lichtenstein's paper at the British Museum and has informed us (*in litt.*) that Lichtenstein's name is available as of that date. The name has been regarded heretofore as a junior synonym of *Siphlonurus luridipennis* (Burmeister, 1839), but it is actually prior to this name when it is credited to Lichtenstein's authorship. The species before Lichtenstein is unidentifiable from the description, no type is known to exist, and even the placement of this as a *Siphlonurus* is extremely uncertain. *Callibaetis hageni* Eaton (*Baetis tessellatus* Hagen not Walker) never can be identified with certainty from the type subimago female. It is probable that Eaton's (1885) description applies to the species known as *Callibaetis carolus* Traver, but whether this is true of the type is uncertain. *Ephemerella unicornis* Needham may be the senior synonym of *E. simplex* McDunnough, but even by comparing fresh material from the type area with the type Burks (1953) was unable to place *E. unicornis* with any confidence. *Cloe quebecensis* Provancher is identifiable only to the genus *Ephemerella* from the female type (See Burks, 1953: 58) and also should be placed as a *nomen dubium*. *Ephemerella consimilis* Walsh is not recognizable from the original description and none of Walsh's specimens of this species are known to exist (See Burks, *op. cit.*: 57). According to Burks (*op. cit.*: 28) *Palingenia puella* (now *Tortopus puella*) can probably never be identified with certainty. The type has not, so far as is known, been located and compared with recently collected material, and the original description is not adequate.

During the compilation of this checklist we have been faced many times with conflicting taxonomic opinions. In many cases our own

[1]The research on which this paper is based was supported by a grant from the University of Utah Research Fund and more recently by the National Science Foundation (NSF G 2514). Accepted for publication Oct. 1, 1956.

experiences with the taxonomy of the forms has influenced our decisions, but generally we have followed the opinion of the last reviser.

We have included in the bibliography only those papers published since or not included in *The Biology of Mayflies*.

Superfamily **HEPTAGENIOIDEA**

Family **Siphlonuridae**

Subfamily **Siphlonurinae**

AMELETUS Eaton, 1885: 210.
- aequivocus McDunnough, 1934: 164.
- alticolus McDunnough, 1934: 163.
- amador Mayo, 1939: 149.
- browni McDunnough, 1933: 278.
- celer McDunnough, 1934: 161.
- celeroides McDunnough, 1934: 162.
- connectina McDunnough, 1939: 50.
- connectus McDunnough, 1936: 209.
- cooki McDunnough, 1929: 174.
- dissitus Eaton, 1885: 210.
- exquisitus Eaton, 1885: 212.
- facilis Day, 1952: 24.
- falsus McDunnough, 1938: 30.
- imbellis Day, 1952: 23.
- lineatus Traver, 1932: 194.
- ludens Needham, 1905: 36.
- monta Mayo, 1952: 93.
- oregonensis McDunnough, 1933: 157.
- querulus McDunnough, 1938: 29.
- shepherdi Traver, 1934: 238.
- similior McDunnough, 1928: 9
- sparsatus McDunnough, 1931: 89.
- subnotatus Eaton, 1885: 211.
- suffusus McDunnough, 1936: 210.
- tertius McDunnough, 1938: 27.
- tuberculatus McDunnough, 1939: 50.
- validus McDunnough, 1923: 50.
- vancouverensis McDunnough, 1933:157.
- velox Dodds, 1923: 105.
- vernalis McDunnough, 1924: 115.

EDMUNDSIUS Day, 1953: 19.
- agilis Day, 1953: 22.

ACANTHAMETROPUS Tshernova, 1948. 1453 (=Metreturus Burks, 1953: 146, *New synonymy*).
- pecatonica Burks, 1953: 147, *New combination*.

PARAMELETUS Bengtsson, 1908: 242.
- chelifer Bengtsson, 1908: 242.
- columbiae McDunnough, 1938: 31.
- croesus (McDunnough, 1923: 48).
- midas (McDunnough, 1923: 49).

SIPHLONISCA Needham, 1909: 72.
- aerodromia Needham, 1909: 72.

SIPHLONURUS Eaton, 1868: 89.
- alternatus (Say, 1824: 304).
  - *annulata* Walker, 1853: 567.
- autumnalis McDunnough, 1931: 89.
- barbaroides McDunnough, 1929: 174.
- barbarus McDunnough, 1924: 225.
- columbianus McDunnough, 1925: 187.
- decorus Traver, 1932: 182.
- inflatus McDunnough, 1931: 90.
- luridipennis (Burmeister, 1839: 801).
- marginatus Traver, 1932: 179.
- marshalli Traver, 1934: 236.
- mirus Eaton, 1885: 221.
- noveboracana Lichtenstein, 1796: III, 193, 52. *nomen dubium*.
- occidentalis Eaton, 1885: 218.
- phyllis McDunnough, 1923: 49.
- quebecensis (Provancher, 1878: 127).
  - *triangularis* Clemens, 1915: 250.
- rapidus McDunnough, 1924: 75.
- securifer McDunnough, 1926: 301.
- spectabilis Traver, 1934: 233.
  - *maria* Mayo, 1939: 145.
- typicus Eaton, 1885: 222.
  - *berenice* McDunnough, 1923: 49.
  - *novangliae* McDunnough, 1924: 75.

Subfamily **Isonychiinae**

ISONYCHIA Eaton, 1871: 134.
- annulata Traver, 1932: 204.
- arida (Say, 1839: 42).
- aurea Traver, 1932: 224.
- bicolor (Walker, 1853: 552).
  - *albomanicatus* (Needham, 1905: 31).
- christina Traver, 1934: 240.
- circe Traver, 1934: 242.
- diversa Traver, 1934: 244.
- fattigi Traver, 1934: 245.
- georgiae McDunnough, 1931: 159.
- harperi Traver, 1934: 246.
- intermedia (Eaton, 1885: 207).
- matilda Traver, 1934: 248.
- notata Traver, 1932: 210.
- obscura Traver, 1932: 217.
- pacoleta Traver, 1932: 218.
- pictipes Traver, 1934: 250.
- rufa McDunnough, 1931: 162.
- sadleri Traver, 1934: 251.
- sayi Burks, 1953: 110.
- serrata Traver, 1932: 222.
- sicca campestris McDunnough, 1931: 161.
- sicca manca Eaton, 1871: 134.
- sicca sicca (Walsh, 1862: 371).
- similis Traver, 1932: 213.
- thalia Traver, 1934: 253.
- tusculanensis Berner, 1948: 117.
- velma Needham, 1932: 273.

Family **Oligoneuriidae**

Subfamily **Oligoneuriinae**

HOMOEONEURIA Eaton, 1881: 192.
- ammophila (Spieth, 1938: 1), *New combination*

LACHLANIA Hagen, 1868: 373.
- powelli Edmunds, 1951: 327.
- saskatchewanensis Ide, 1941: 154.

Family **Heptageniidae**

Subfamily **Heptageniinae**

ANEPEORUS McDunnough, 1925: 190.
- rusticus McDunnough, 1925: 190.
- simplex (Walsh, 1863: 204).

ARTHROPLEA Bengtsson, 1908: 239.
- bipunctata (McDunnough, 1924: 76).

CINYGMA Eaton, 1885: 247.
- dimicki McDunnough, 1934: 182.
- integrum Eaton, 1885: 248.
- lyriformis (McDunnough, 1924: 226)

CINYGMULA McDunnough, 1933: 75.
- confusa (McDunnough, 1924: 131).
- gartrelli McDunnough, 1934: 182.
- kootenai McDunnough, 1943: 3.
- mimus (Eaton, 1885: 249).
- par (Eaton, 1885: 249).
  - *hyalina* McDunnough, 1924: 132, *New synonymy*.
- ramaleyi (Dodds, 1932: 101).
  - *tollandi* (Dodds, 1923: 109).
- reticulata McDunnough, 1934: 184.
- subaequalis (Banks, 1914: 615).
  - *atlantica* (McDunnough, 1924: 131), *New synonymy*.

tarda (McDunnough, 1929: 178).
tioga Mayo, 1952: 184.
uniformis McDunnough, 1934: 183.

EPEORUS EATON, 1881: 26.
sg. IRON Eaton, 1883: pl. 24, fig. 44.
albertae McDunnough, 1924: 129.
youngi Traver, 1935: 412.
deceptivus (McDunnough, 1924: 132).
dispar Traver, 1933: 161.
dulciana McDunnough, 1935: 103.
fragilis Morgan, 1911: 104.
tenuis Traver, 1935: 412.
frisoni Burks, 1946: 608.
hesperus (Banks, 1924: 424).
sancta-gabriel Traver, 1935: 410, *New synonymy*.
langunitas Traver, 1935: 405.
longimanus (Eaton, 1885: 245).
proprius Traver, 1935: 408.
namatus Burks, 1946: 607.
pleuralis (Banks, 1910: 201).
fraudator Traver, 1935: 402.
confusus Traver, 1935: 398.
punctatus McDunnough, 1925: 189.
rubidus Traver, 1933: 158.
subpallidus Traver, 1937: 54.
suffusus McDunnough, 1925: 189.
vitrea (Walker, 1853: 555).
humeralis Morgan, 1911: 105.
sg. IRONODES Traver, 1935: 32.
arctus Traver, 1935: 33.
californicus (Banks, 1910: 202).
flavipennis Traver, 1935: 33.
geminatus (Eaton, 1885: 250).
lepidus Traver, 1935: 35.
nitidus (Eaton, 1885: 246).
sg. IRONOPSIS Traver, 1935: 36.
grandis (McDunnough, 1924: 130).
permagnus Traver, 1935: 37.

HEPTAGENIA Walsh, 1863: 197.
adaequata McDunnough, 1924: 120.
aphrodite McDunnough, 1926: 194.
criddlei McDunnough, 1927: 261.
cruentata Walsh, 1863: 205.
reversalis McDunnough, 1924: 118.
diabasia Burks, 1946: 610.
dolosa Traver, 1935: 344.
elegantula (Eaton, 1885: 253).
coxalis Banks, 1914: 615.
querula McDunnough, 1924: 119.
flavescens (Walsh, 1862: 373).
hebe McDunnough, 1924: 122.
horrida McDunnough, 1926: 301.
inconspicua McDunnough, 1924: 118.
julia Traver, 1933: 149.
juno McDunnough, 1924: 121.
kennedyi McDunnough, 1924: 225.
lucidipennis (Clemens, 1913: 329).
maculipennis Walsh, 1863: 206.
manifesta (Eaton, 1885: 253).
marginalis Banks, 1910: 198.
minerva McDunnough, 1924: 121.
otiosa McDunnough, 1935: 104.
patoka Burks, 1946: 612.
perifida McDunnough, 1926: 301.
persimplex McDunnough, 1929: 179.
pulla (Clemens, 1913: 330).
rodocki Traver, 1935: 357.
rosea Traver, 1935: 358.
rubroventris Traver, 1935: 359.
rusticalis McDunnough, 1931: 92.
simplicioides McDunnough, 1924: 120.
solitaria McDunnough, 1924: 119.
spinosa Traver, 1933: 153.
thetis Traver, 1935: 362.
townesi Traver, 1935: 363.
unbratica McDunnough, 1931: 92.
walshi McDunnough, 1926: 193.

RHITHROGENA Eaton, 1881: 23.
amica Traver, 1935: 373.
anomala McDunnough, 1928: 239.
brunnea (Hagen, 1875: 581).
hageni Eaton, 1885: 253.
brunneotincta McDunnough, 1933: 280.
decora Day, 1954: 19.
doddsi McDunnough, 1926: 196.
exilis Traver, 1933: 166.
fasciata Traver, 1933: 170.
flavianula (McDunnough, 1924: 225).
fuscifrons Traver, 1933: 168.
futilis McDunnough, 1934: 187.
gaspeensis McDunnough, 1933: 279.
impersonata (McDunnough, 1925: 191).
jejuna Eaton, 1885: 252.
fusca (Walker, 1853: 568), not Burmeister, 1839: 800.
morrisoni (Banks, 1924: 424).
pellucida Daggy, 1945: 383.
petulans (Seemann, 1927: 42).
robusta Dodds, 1923: 103.
rubicunda Traver, 1937: 46.
sanguinea Ide, 1954: 349.
uhari Traver, 1933: 165.
undulata (Banks, 1924: 425).
virilis McDunnough, 1934: 187.

STENONEMA Traver, 1933: 173.
alabamae Traver, 1937: 79.
annexum Traver, 1933: 179.
areion Burks, 1953: 163.
ares Burks, 1953: 170.
bipunctatum (McDunnough, 1926: 191).
candidum Traver, 1935: 308.
carolina (Banks, 1914: 616).
exiguum Traver, 1933: 201.
femoratum femoratum (Say, 1823: 162).
femoratum scitulum Traver, 1935: 330.
femoratum tripunctatum (Banks, 1910: 199).
birdi Traver, 1935: 306.
fuscum (Clemens, 1913: 254).
gildersleevei Traver, 1935: 315.
integrum (McDunnough, 1924: 9).
bellum Traver, 1933: 202.
wabasha Daggy, 1945: 378.
interpunctatum canadense (Walker, 1853: 569).
ohioense Traver, 1935: 322.
interpunctatum frontale (Banks, 1910: 199).
conjunctum Traver, 1935: 309.
majus Traver, 1935: 320.
proximum Traver, 1935: 325.
interpunctatum heterotarsale McDunnough, 1933: 42.
interpunctatum interpunctatum (Say, 1839: 41).
affine Traver, 1933: 184.
flaveola Pictet, 1843: 186.
pallidum Traver, 1933: 181.
ithaca (Clemens and Leonard, 1925: 17).
lepton Burks, 1946: 614.
luteum (Clemens, 1913: 252).
mediopunctatum (McDunnough, 1926: 191).
metriotes Burks, 1953: 174.
minnetonka Daggy, 1945: 376.
modestum (Banks, 1910: 202).
nepotellum McDunnough, 1933: 20.
pudicum (Hagen, 1861: 39).
pulchellum (Walsh, 1862: 375).
rubromaculatum (Clemens, 1913: 256).
rubrum (McDunnough, 1926: 192).
smithae Traver, 1937: 77.
terminatum (Walsh, 1862: 376).
placita Banks, 1910: 199).
varium Traver, 1933: 192.
vicarium (Walker, 1853: 565).
tesselata (Walker, 1853: 566).
rivulicolus (McDunnough, 1933: 40).

Subfamily **Pseudironinae**

PSEUDIRON McDunnough, 1931: 91.
centralis McDunnough, 1931: 91.
meridionalis Traver, 1935: 437.

Family **Ametropodidae**

Subfamily **Ametropodinae**

AMETROPUS Albarda, 1878: 129.
albrighti Traver, 1935: 431.
neavei McDunnough, 1928: 9.

Subfamily **Metretopodinae**

METRETOPUS Eaton, 1901: 253.
borealis Eaton, 1871: 137.
norvegicus Eaton, 1901: 254.

SIPHLOPLECTON Clemens, 1915: 258.
basale (Walker, 1853: 565).
flexus (Clemens, 1913: 338).
costalense Spieth, 1938: 1
interlineatum (Walsh, 1863: 190).
signatum Traver, 1932: 186.
speciosum Traver, 1932: 191.

Family **Baetidae**

Subfamily **Baetinae**

APOBAETIS Day, 1955: 126.
indeprensus Day, 1955: 127.

BAETIS Leach, 1815: 137.
adonis Traver, 1935: 680.
akataleptos McDunnough, 1926: 188.
alius Day, 1954: 32.
amplus (Traver, 1932: 233).
anachris Burks, 1953: 133.
australis Traver, 1932: 230.
baeticatus Burks, 1953: 129.
bicaudatus Dodds, 1923: 110.
minimus Dodds, 1923: 113, *New synonymy*.
brunneicolor McDunnough, 1925: 173.
cingulatus McDunnough, 1925: 216.
cleptis Burks, 1953: 130.
curiosus (McDunnough, 1923: 43).
devinctus Traver, 1935: 684.
diablus Day, 1954: 30.
elachistus Burks, 1953: 127.
endymion Traver, 1935: 686.
ephippiatus Traver, 1935: 687.
erebus Traver, 1935: 687.
flavistriga McDunnough, 1921: 120.
foemina McDunnough, 1936: 33.
frivolus McDunnough, 1925: 174.
frondalis McDunnough, 1925: 173.
harti McDunnough, 1924: 7.
herodes Burks, 1953: 130.
hiemalis Leonard, 1950: 155.
hudsonicus Ide, 1937: 221.
incertans McDunnough, 1925: 220.
insignificans McDunnough, 1926: 300.
intercalaris McDunnough, 1921: 118.
lasallei Banks, 1924: 425.
intermedius Dodds, 1923: 110.
jesmondensis McDunnough, 1938: 25.
lapponica (Bengtsson, 1912: 111).
leechi Day, 1954: 29.
levitans McDunnough, 1925: 216.
macdunnoughi Ide, 1937: 230.
moffati Dodds, 1923: 112.
nanus McDunnough, 1923: 42.
ochris Burks, 1953: 132.
pallidulus McDunnough, 1924: 8.
palisadi Mayo, 1952: 95.
parallelus Banks, 1924: 425.
parvus Dodds, 1923: 113.
persecuta McDunnough, 1939: 52.
phoebus McDunnough, 1923: 41.
phyllis Burks, 1953: 134.
piscatoris Traver, 1935: 697.
pluto McDunnough, 1925: 218.
posticatus (Say, 1824: 162).
propinquus (Walsh, 1863: 207).
dardanus McDunnough, 1923: 41.
pygmaeus (Hagen, 1861: 54).
quilleri Dodds, 1923: 112.
rusticans McDunnough, 1925: 217.
spiethi Berner, 1940: 52.
spinosus McDunnough, 1925: 174.
sulfurosus Day, 1954: 33.
thermophilos McDunnough, 1926: 188.
tricaudatus Dodds, 1923: 111.
unicolor (Hagen, 1861: 54).
hageni Eaton, 1885: 169.
vagans McDunnough, 1925: 219.

BAETODES Needham and Murphy, 1924: 55.
species?, Edmunds, 1950: 203.

CALLIBAETIS Eaton, 1881: 196.
americanus Banks, 1900: 250.
brevicostatus Daggy, 1945: 388.
californicus Banks, 1900: 249.
carolus Traver, 1935: 663.
coloradensis Banks, 1900: 250.
doddsi Traver, 1935: 664.
vitrea Dodds, 1923: 100 not Navas, 1918: 81.
ferrugineus (Walsh, 1862: 379).
floridanus Banks, 1900: 249.
fluctuans (Walsh, 1862: 379).
fuscus Dodds, 1923: 100.
hageni (Eaton, 1885: 192), *nomen dubium*.
tessellata Hagen, 1861: 50 not Walker, 1853: 566.
hebes Upholt, 1936: 120.
montanus Eaton, 1885: 196.
nigritus Banks, 1918: 12.
claudiae Edmunds, 1945: 169, *nomen nudum*.
pacificus Seemann, 1927: 49.
pallidus Banks, 1900: 251.
pictus (Eaton, 1871: 122).
pretiosus Banks, 1914: 615.
semicostatus Banks, 1914: 614.
signatus Banks, 1918: 11.
skokianus Needham, 1903: 215.
traverae Upholt, 1937: 86.

CENTROPTILUM Eaton, 1869: 132.
album McDunnough, 1926: 189.
asperatum Traver, 1935: 708.
bellum McDunnough, 1924: 96.
bifurcatum McDunnough, 1924: 96.
caliginosum McDunnough, 1925: 175.
conturbatum McDunnough, 1929: 171.
convexum Ide, 1930: 222.
elsa Traver, 1935: 713.
fragile McDunnough, 1923: 42.
hobbsi Berner, 1946: 77.
infrequens McDunnough, 1924: 98.
intermediale McDunnough, 1931: 87.
oreophilum Edmunds, 1954: 1.
ozburni McDunnough, 1924: 97.
quaesitum McDunnough, 1931: 87.
rivulare Traver, 1935: 716.
rufostrigatum McDunnough, 1924: 95.
bistrigatum Daggy, 1945: 389.
selanderorum Edmunds, 1954: 2.
semirufum McDunnough, 1926: 189.
simile McDunnough, 1924: 97.
venosum Traver, 1935: 718.
victoriae McDunnough, 1938: 27.
viridocularis Berner, 1940: 39.
walshi McDunnough, 1929: 173.

CLOEON Leach, 1815: 137.
dipterum (Linnaeus, 1761: 377). (Adventive).
implicatum McDunnough, 1924: 113.
inanum McDunnough, 1924: 113.
ingens McDunnough, 1923: 44.
insignificans McDunnough, 1925: 186.
mendax (Walsh, 1862: 381).
minor McDunnough, 1926: 190.
rubropictum McDunnough, 1923: 43.
simplex McDunnough, 1925: 185.
triangulifer McDunnough, 1931: 88.
vicinum (Hagen, 1861: 54).

NEOCLOEON Traver, 1932: 365.
alamance Traver, 1932: 367.

PARDACLOEODES Day, 1955: 121.
abitus Day, 1955: 122.

PSEUDOCLOEON Klapalek, 1905: 105.
alachua Berner, 1940: 58.
anoka Daggy, 1945: 391.
bimaculatus Berner, 1946: 79.
carolina (Banks, 1924: 426).
chlorops (McDunnough, 1923: 45).
cingulatum McDunnough, 1931: 85.
dubium (Walsh, 1862: 380).
ellioti Daggy, 1945: 392.
etowah Traver, 1935: 726.
futile McDunnough, 1931: 86.
ida Daggy, 1945: 393.
minutum Daggy, 1945: 394.
myrsum Burks, 1953: 139.
parvulum McDunnough, 1932: 210.
punctiventris (McDunnough, 1923: 45).
rubrolaterale McDunnough, 1931: 86.
turbidum McDunnough, 1924: 113.
veteris McDunnough, 1924: 8.
virile (McDunnough, 1923: 46).

Superfamily **LEPTOPHLEBIOIDEA**

Family **Leptophlebiidae**

Subfamily **Leptophlebiinae**

CHOROTERPES Eaton 1881: 194.
albiannulata McDunnough, 1924: 221.
basalis (Banks, 1900: 248).
ferruginea Traver, 1934: 205.
fusca Spieth, 1938: 4.
hubbeli Berner, 1946: 65.
inornata Eaton, 1892: 6.
nanita Traver, 1934: 203.
oklahoma Traver, 1934: 204.
terratoma Seemann, 1927: 46.

HABROPHLEBIA Eaton, 1881: 195.
pusilla Traver, 1932: 118.
vibrans Needham, 1908: 192.
jocosa Banks, 1914: 614.

HABROPHLEBIODES Ulmer, 1920: 39.
americana (Banks, 1903: 235).
betteni (Needham, 1908: 194).
annulata Traver, 1934: 199.
brunneipennis Berner, 1946: 61.

LEPTOPHLEBIA Westwood, 1840: 31.
sg. LEPTOPHLEBIA, sensu strictu.
johnsoni McDunnough, 1924: 73.
gracilis (Traver, 1932: 133).
sg. BLASTURUS Eaton, 1881: 193.
austrina (Traver, 1932: 129).
collina (Traver, 1932: 124).
cupida (Say, 1823: 163).
hebes (Walker, 1853: 538).
concinna (Walker, 1853: 553).
pallipes (Walker, 1853: 553).
ignava (Hagen, 1861: 47).
grandis (Traver, 1932: 127).
gravastella (Eaton, 1884: 102).
intermedia (Traver, 1932: 136).
nebulosa (Walker, 1853: 554).
odonatus (Walsh, 1862: 372).
pacifica (McDunnough, 1933: 155).
vibex (Traver, 1934: 197).

PARALEPTOPHLEBIA Lestage, 1917: 340.
adoptiva (McDunnough, 1929: 169).
assimilis (Banks, 1914: 614).
associata (McDunnough, 1924: 221).
compar Traver, 1934: 193.
bicornuta (McDunnough, 1926: 299).
bradleyi (Needham, 1932: 274).
brunneipennis (McDunnough, 1924: 221).
cachea Day, 1954: 22.
californica Traver, 1934: 195.
clara (McDunnough, 1933: 155).
debilis (Walker, 1853: 569).
separata (Ulmer, 1920: 27).
falcula Traver, 1934: 190.
georgiana Traver, 1934: 191.
gregalis (Eaton, 1884: 98).
invalida (McDunnough, 1926: 297).
guttata (McDunnough, 1924: 95).
helena Day, 1952: 17.
heteronea (McDunnough, 1924: 93).
jeanae Berner, 1955: 245.
moerens (McDunnough, 1924: 94).
mollis (Eaton, 1871: 88).
ontario (McDunnough, 1926: 299).
packi (Needham, 1927: 45).
pallipes (Hagen, 1875: 582).
memorialis (Eaton, 1884: 98).
placeri Mayo, 1939: 152.
praepedita (Eaton, 1884: 99).
quisquilia Day, 1952: 21.
rufivenosa (Eaton, 1884: 99).
sculleni Traver, 1934: 189.
sticta Burks, 1953: 92.
strigula (McDunnough, 1932: 209).
swannanoa (Traver, 1932: 113).
temporalis (McDunnough, 1926: 297).
vaciva (Eaton, 1884: 97).
volitans (McDunnough, 1924: 95).
zayante Day, 1952: 20.

THRAULODES Ulmer, 1920: 33.
arizonicus McDunnough, 1942: 117.
speciosus Traver, 1934: 201.

TRAVERELLA Edmunds, 1948: 141.
albertana (McDunnough, 1931: 82).
presidiana (Traver, 1934: 199).

Family **Ephemerellidae**

Subfamily **Ephemerellinae**

EPHEMERELLA Walsh, 1862: 377.
aestiva McDunnough, 1931: 64.
allegheniensis Traver, 1934: 221.
argo Burks, 1949: 232.
attenuata McDunnough, 1925: 42.
aurivillii (Bengtsson, 1908: 243).
aaroni Eaton, 1908: 149.
norda McDunnough, 1924: 223.
concinnata Traver, 1934: 219.
autumnalis McDunnough, 1934: 158.
bicolor Clemens, 1913: 336.
bicoloroides McDunnough, 1938: 23.
catawba Traver, 1932: 153.
cherokee Traver, 1937: 71.
choctawhatchee Berner, 1946: 71.
cognata Traver, 1934: 231.
coloradensis Dodds, 1923: 97.
columbiella McDunnough, 1935: 97.
conestee Traver, 1932: 168.

consimilis Walsh, 1862: 378, *nomen dubium*.
cornuta Morgan, 1911: 114.
cornutella McDunnough, 1931: 82.
coxalis McDunnough, 1926: 186.
deficiens Morgan, 1911: 111.
atrescens McDunnough, 1925: 43.
delantala Mayo, 1952: 94.
depressa Ide, 1930: 212.
doddsi Needham, 1927: 111.
doris Traver, 1934: 208.
dorothea Needham, 1908: 190.
euterpe Traver, 1934: 213.
excrucians Walsh, 1862: 377.
semiflava McDunnough, 1926: 300.
flavilinea McDunnough, 1926: 188.
flavitincta McDunnough, 1934: 155.
fratercula McDunnough, 1925: 213.
frisoni McDunnough, 1927: 10.
funeralis McDunnough, 1925: 210.
glacialis Traver, 1934: 207.
glacialis carsona Day, 1952: 32.
grandis Eaton, 1884: 128.
hecuba Eaton, 1884: pl. 40.
heterocaudata McDunnough, 1929: 170.
hirsuta Berner, 1946: 70.
hystrix Traver, 1934: 212.
spinosa Mayo, 1951: 122.
inermis Eaton, 1884: 127.
infrequens McDunnough, 1924: 223.
ingens McDunnough, 1934: 154.
invaria (Walker, 1853: 568).
jacobi McDunnough, 1939: 49.
lapidula McDunnough, 1935: 96.
lata Morgan, 1911: 112.
inflata McDunnough, 1926: 187.
levis Day, 1954: 15.
lita Burks, 1949: 235.
lodi Mayo, 1952: 179.
longicornis Traver, 1932: 164.
lutulenta Clemens, 1913: 335.
lineata Clemens, 1913: 336.
maculata Traver, 1934: 216.
margarita Needham, 1927: 114.
mcheneri Traver, 1934: 227.
minimella McDunnough, 1931: 63.
molita McDunnough, 1930: 57.
mollitia Seemann, 1927: 44.
needhami McDunnough, 1925: 171.
ora Burks, 1949: 235.
pelosa Mayo, 1951: 121.
proserpina Traver, 1934: 223.
yosemite Traver, 1934: 225.
prudentalis McDunnough, 1931: 40.
quebeccensis (Provancher, 1876: 267), *nomen dubium*.
rotunda Morgan, 1911: 113.
feminina Needham, 1924: 309.
septentrionalis McDunnough, 1925: 171.
serrata Morgan, 1911: 109.
serratoides McDunnough, 1931: 83.
sierra Mayo, 1952: 96.
simplex McDunnough, 1925: 41.
soquele Day, 1954: 18.
sordida McDunnough, 1925: 42.
spinifera Needham, 1927: 110.
subvaria McDunnough, 1931: 84.
temporalis McDunnough, 1924: 73.
teresa Traver, 1934: 230.
tibialis McDunnough, 1924: 224.
angusta Traver, 1934: 211.
trilineata Berner, 1946: 67.
tuberculata Morgan, 1911: 112.
unicornis Needham, 1905: 45, *nomen dubium* (?=simplex McDunnough).
verisimilis McDunnough, 1930: 57.
vernalis Banks, 1914: 614.
inconstans Traver, 1932: 149.
walkeri Eaton, 1884: 129.
fuscata (Walker, 1853: 570), not Stephens, 1835: 40.
bispina Needham, 1905: 43.
wayah Traver, 1932: 172.
wilsoni Mayo, 1952: 100.

Family **Tricorythidae**

Subfamily **Leptohyphinae**

LEPTOHYPHES Eaton, 1882: 208.
species? Burks, 1953: 55.

TRICORYTHODES Ulmer, 1920: 51.
albilineatus Berner, 1946: 72.
allectus (Needham, 1905: 47).
atratus (McDunnough, 1923: 39).
explicatus (Eaton, 1892: 11).
fallax Traver, 1935: 634.
fictus Traver, 1935: 635.
minutus Traver, 1935: 636.
fallacina McDunnough, 1939: 53, *New synonymy*.
peridius Burks, 1953: 48.
stygiatus McDunnough, 1931: 267.
texanus Traver, 1935: 638.

Superfamily **CAENOIDEA**

Family **Caenidae**

Subfamily **Caeninae**

BRACHYCERCUS Curtis, 1834: 122.
flavus Traver, 1935: 640.
lacustris (Needham, 1918: 249).
pallidus (Ide, 1930: 218), not Tshernova, 1928: 114.
idei Lestage, 1931: 119, n. n. for *pallidus* Ide.
maculatus Berner, 1946: 76.
nitidus (Traver, 1932: 139).
prudens (McDunnough, 1931: 264).

CAENIS Stephens, 1835: 61.
amica Hagen, 1861: 55.
anceps Traver, 1935: 645.
delicata Traver, 1935: 647.
diminuta Walker, 1853: 584.
forcipata McDunnough, 1931: 262.
gigas Burks, 1953: 53.
hilaris (Say, 1839: 43).
jocosa McDunnough, 1931: 260.
latipennis Banks, 1907: 14.
punctata McDunnough, 1931: 259.
ridens McDunnough, 1931: 256.
simulans McDunnough, 1931: 263.
tardata McDunnough, 1931: 260.

Family **Neoephemeridae**

Subfamily **Neoephemerinae**

NEOEPHEMERA McDunnough, 1925: 168.
bicolor McDunnough, 1925: 168.
compressa Berner, 1956: 34.
purpurea (Traver, 1931: 105).
youngi Berner, 1953: 145.

Superfamily **EPHEMEROIDEA**

Family **Potamanthidae**

Subfamily **Potamanthinae**

POTAMANTHUS Pictet, 1845: 197.
diaphanus Needham, 1908: 193.
distinctus Traver, 1935: 280.
inequalis Needham, 1909: 74.
myops (Walsh, 1863: 207).
medius Banks, 1908: 259.
neglectus Traver, 1935: 282.
rufous Argo, 1927: 323.
verticis (Say, 1839: 42).
flaveola (Walsh, 1862: 377).
walkeri Ide, 1935: 119.

Family **Ephemeridae**

Subfamily **Ephemerinae**

EPHEMERA Linnaeus, 1758: 546.
blanda Traver, 1932: 104.
compar Hagen, 1875: 578.
guttulata Pictet, 1843: 135.
simulans Walker, 1853: 536.
natata (Walker, 1853: 551).
decora Walker, 1853: 537.
traverae Spieth, 1938: 5.
triplex Traver, 1935: 253.
varia Eaton, 1883: 69.

HEXAGENIA Walsh, 1863: 197.
atrocaudata McDunnough, 1924: 92.
bilineata (Say, 1824: 303).
limbata limbata (Serville, in Guerin-Meneville, 1829: 34).
variabilis Eaton, 1883: 55.
limbata californica Upholt, 1937: 85.
limbata occulta (Walker, 1853: 551).
mingo Traver, 1931: 597.
limbata venusta Eaton, 1883: 54.
pallens Traver, 1935: 271.
limbata viridescens (Walker, 1853: 551).
angulata Walker, 1853: 564.
munda affiliata McDunnough, 1927: 119.
munda elegans Traver, 1931: 594.
weewa Traver, 1931: 605.
kanuga Traver, 1937:29.
munda marilandica Traver, 1931: 599.
carolina Traver, 1931: 601.
rosacea Traver, 1931: 607.
munda munda Eaton, 1883: 53.
munda orlando Traver, 1931: 608.
recurvata Morgan, 1913: 395.
rigida McDunnough, 1924: 90.

PENTAGENIA Walsh, 1863: 196.
robusta McDunnough, 1926: 185.
vittigera (Walsh, 1862: 373).
quadripunctata Walsh, 1863: 198.

Family **Polymitarcidae**

Subfamily **Polymitarcinae**

EPHORON Williamson, 1802: 71.
album (Say, 1824: 305).
leukon Williamson, 1802: 71.

Subfamily **Campsurinae**

CAMPSURUS Eaton, 1868: 83.
decoloratus (Hagen, 1861: 43).

TORTOPUS Needham and Murphy, 1924: 23.
circumfluus Ulmer, 1942: 110.
incertus (Traver, 1935: 286).
primus (McDunnough, 1924: 7).
manitobensis (Ide, 1941: 155).
puella (Pictet, 1843: 145), *nomen dubium*.

Superfamily **PROSOPISTOMATOIDEA**

Family **Baetiscidae**

Subfamily **Baetiscinae**

BAETISCA Walsh, 1862: 378.
bajkovi Neave, 1934: 166.
callosa Traver, 1931: 57.
carolina Traver, 1931: 51.
thomsenae Traver, 1937: 61.
escambiensis Berner, 1955: 2
gibbera Berner, 1955: 11.
lacustris McDunnough, 1932: 214.
laurentina McDunnough, 1932: 214.
obesa (Say, 1839: 43).
rogersi Berner, 1940: 156.
rubescens (Provancher, 1878: 127).

BIBLIOGRAPHY

Albarda, H. 1878. Descriptions of three new European Ephemeridae. Ent. Month. Mag. 15: 128–30.

Banks, N. 1918. New neuropteroid insects. Bull. Mus. Comp. Zool. 62: 1–22, 26 figs.

Bengtsson, S. 1908. Berattelse ofver en resa i entomologiskt syfte till mellersta Sverige Sommaren 1907. Kungliga Svenska Vetenskapsakademien Arsbok 6: 237–46.

1912. New Ephemeriden aus Schweden. Ent. Tidskr. 33: 107–17.

Berner, L. 1940. Baetine mayflies from Florida (Ephemeroptera). Florida Ent. 23: 33–45; 49–62, 2 pls.

1940. *Baetisca rogersi*, a new mayfly from northern Florida. Canadian Ent. 72: 156–60, 5 figs.

1946. New species of Florida mayflies (Ephemeroptera). Florida Ent. 28: 60–82, 1 pl.

1948. A new species of mayfly from Tennessee. Ent. News, 59: 117–20, 3 figs.

1950. The mayflies of Florida. Univ. Florida Studies, Biol. Sci. Series 4(4), XII+267 pp., 88 figs., 24 pls., 19 maps.

1953. New mayfly records from Florida and a description of a new species. Florida Ent., 36: 145–9, 3 figs.

1955. A new species of *Paraleptophlebia* from the southeast (Ephemeroptera, Leptophlebiidae). Proc. Ent. Soc. Washington 57: 245–7, 2 figs.

1955. The southeastern species of *Baetisca*. Quart. Jour. Florida Acad. Sci. 18: 1–19, 23 figs.

1956. The genus *Neoephemera* in North America (Ephemeroptera: Neoephemeridae). Ann. Ent. Soc. America 49: 33–42, 26 figs.

Burks, B. D. 1946. New heptagenine mayflies. Ann. Ent. Soc. America 39: 607–15, 10 figs.

1949. New species of *Ephemerella* from Illinois (Ephemeroptera). Canadian Ent. 79: 232–6, 7 figs. (Publication dated 1947).

1953. The mayflies, or Ephemeroptera, of Illinois. Bull. Ill. Nat. Hist. Surv. 26(Art. 1): 1–216, 395 figs.

Burmeister, H. 1839. Ephemerina, *in* Handbuch der Entomologie, Vol. II, part II, pp. 788–804. Berlin.

Curtis, J. 1834. Descriptions of some nondescript British species of mayflies of anglers. Lond. and Edinb. Philos. Mag. 3(20): 120–5; (21): 212–18.

Daggy, R. H. 1945. New species and previously undescribed naiads of some Minnesota mayflies (Ephemeroptera). Ann. Ent. Soc. America 38: 373–96, 2 pls., 4 text figs.

Day, W. C. 1952. New species and notes on California mayflies (Ephemeroptera). Pan-Pacific Ent. 28: 17–39, 8 pls.

1953. A new mayfly genus from California (Ephemeroptera). Pan-Pacific Ent. 29: 19–24, 2 pls.

1954. New species and notes on California mayflies, II. Pan-Pacific Ent. 30: 15–29, 14 figs.

1954. New species of California mayflies in the genus *Baetis*. Pan-Pacific Ent. 30: 29–34, 8 figs.

1955. New genera of mayflies from California (Ephemeroptera). Pan-Pacific Ent. 31: 121–37, 27 figs.

Eaton, A. E. 1868. An outline of a re-arrangement of the genera of Ephemeridae. Ent. Month. Mag. 5: 82–91.

1882. An announcement of new genera of the Ephemeridae. Ent. Month. Mag. 18: 207–8.

1901. Ephemeridae collected by Herr E. Strand in South and Artic Norway. Ent. Month. Mag. 37: 252–5, 2 figs.

Edmunds, G. F. Jr. 1945. Ovoviviparous mayflies of the genus *Callibaetis* (Ephemeroptera: Baetidae). Ent. News 56: 169–71.

1948. A new genus of mayflies from western North America (Leptophlebiinae). Proc. Biol. Soc. Washington 61: 141–8, 2 pls.

1950. New records of the mayfly genus *Baetodes*, with notes on the genus. Ent. News 61: 203–5.

1951. New species of Utah mayflies I. Oligoneuriidae (Ephemeroptera). Proc. Ent. Soc. Washington 53: 327–31, 1 pl.

1954. New species of Utah mayflies II. Baetidae, *Centroptilum* (Ephemeroptera). Proc. Ent. Soc. Washington 56: 1–4, 1 pl.

Edmunds, G. F., Jr., and **J. R. Traver.** 1954. An outline of a reclassification of the Ephemeroptera. Proc. Ent. Soc. Washington 56: 236–40.

Hagen, H. A. 1868. On *Lachlania abnormis*, a new genus and species from Cuba belonging to the Ephemerina. Proc. Bost. Soc. Nat. Hist. 11: 372–4.

1875. Report on the Pseudo-Neuroptera and Neuroptera collected by Lieut. W. L. Carpenter in 1873, in Colorado. Report Geolog. Survey of Territories for 1873: 571–606.

Ide, F. P. 1930. Contribution to the biology of Ontario mayflies with descriptions of new species. Canadian Ent. 62: 204–13; 218—31, 3 pls.

1937. Descriptions of eastern North American species of Baetine mayflies with particular reference to the nymphal stages. Canadian Ent. 69: 219–31, 235–43, 5 pls.

1941. Mayflies of two tropical genera, *Lachlania* and *Campsurus*, from Canada with descriptions. Canadian Ent. 73: 153–6, 3 figs.

1954. The nymph of *Rhithrogena impersonata* (Ephemerida) and a new closely related species from the same locality in Southern Ontario. Canadian Ent. 86: 348–56, 9 figs.

Klapalek, F. 1905. Plecopteren and Ephemeriden aus Java, gesammelt von Prof. M. Kraepilin 1904. Mitt. Nat. Mus. Hamburg 22: 103–7, 1 fig.

Leach, W. E. 1815. Entomology. Brewster Edinburgh Encyclopaedia, Edinburgh, Vol. 9, Pt. 1, pp. 57–172.

Leonard, J. W. 1950. A new *Baetis* from Michigan (Ephemeroptera). Ann. Ent. Soc. America 43: 155–9, 1 fig., 1 pl.

Lestage, J. A. 1931. Notes à propos de l'homonymie de deux Éphéméroptères. Bull. Ann. Soc. Ent. Belg. 71: 119.

Lichtenstein, A. A. H. 1796. Catalogus musei zoologici ditissimi Hamburgi III Febr. 1796 auctionis lege distrahendi. Hamburg. 222 pp. (Catalogue Holthusien Museum collections.)

Linnaeus, C. 1758. Systema Naturae, 10th Edition. Pp. 824+2. Holmiae.

1761. Fauna Suecicae. 2nd Ed. Pp. 48+578 pages. Stockholm.

McDunnough, J. 1921. Two new Canadian mayflies (Ephemeridae). Canadian Ent. 53: 117–20, 1 pl.

1936. A new arctic Baetid (Ephemeroptera). Canadian Ent. 68: 33–35, 1 pl.

1936. Further notes on the genus Ameletus with descriptions of new species (Ephemeroptera). Canadian Ent. 68: 207–11, 2 figs.

1938. New species of North American Ephemeroptera with critical notes. Canadian Ent. 70: 23–34, 1 pl., 2 figs.

1939. New British Columbian Ephemeroptera. Canadian Ent. 71: 49–54, 1 pl.

1942. An apparently new *Thraulodes* from Arizona (Ephemerida). Canadian Ent. 74: 117.

1943. A new *Cinygmula* from British Columbia (Ephemeroptera). Canadian Ent. 75: 3, 1 fig.

Mayo, V. K. 1939. New western Ephemeroptera. Pan-Pacific Ent. 15: 145–154, 3 pls.

1951. New Western Ephemeroptera II. Pan-Pacific Ent. 27: 121–5, 1 pl.

1952. New Western Ephemeroptera, III. Pan-Pacific Ent. 28: 93–103, 3 pls.

1952. New Western Ephemeroptera, IV, with notes. Pan-Pacific Ent. 28: 179–86, 1 pl.

Needham, J. G. 1908. New data concerning mayflies and dragonflies of New York. New York State Mus. Bull. 124: 188–94, 1 pl.

1909. A peculiar new mayfly from Sacandaga Park. New York State Mus. Bull. 134: 71–75.

Needham, J. G., J. R. Traver, and **Yin-Chi Hsu.** 1935. The biology of mayflies with a systematic account of North American species. Comstock, Ithaca, N. Y.

Provancher, L. 1876. Petit fauna entomologique du Canada, Nevroptères, Fam. III, Éphémérides. Nat. Canad. 8: 264–8.

1878. Additions et corrections aux Nevroptères de la Province de Quebec. Nat. Canad. 10: 124–47.

Say, T. 1823. Descriptions of insects belonging to the order Neuroptera Linn., Latr. collected by the expedition authorized by J. C. Calhoun, Secretary of War, under the command of Major S. H. Long. West. Quart. Rept. 2: 160–5.

1824. *In* Keating, W. H., Narrative of an expedition to the source of St. Peters River, Lake Winnipeek, Lake of Woods etc. etc. by order of The Hon. J. C. Calhoun, Secretary of War, under the command of Stephen H. Long, Major U.S.T.E. Vol. II, Appendix, pp. 303–5. Cary and Lea, Philadelphia.

1839. Descriptions of new North American neuropterous insects and observations on some already described. Jour. Acad. Nat. Sci. Phila. 8: 9–46.

Serville, J. G. A. 1829. *In* Guérin-Méneville, Iconographie Règne Animal de G. Cuvier, Vol. 3: 384; Insects, pl. 60, fig. 7.

Spieth, H. T. 1938. Two interesting mayfly nymphs with a description of a new species. Amer. Mus. Novitates 970: 1–7, 2 pls.

1938. Taxonomic studies on the Ephemerida, I: Description of New North American species. Amer. Mus. Novitates 1002: 1–11, 8 figs.

Stephens, J. F. 1835. Illustrations of British entomology Vol. 6, 240 pp., 7 pls.

Traver J. R. 1935. Part II. Systematic, pp. 237–739, *in* Needham, Traver, and Hsu, *op. cit.*

1937. Notes on mayflies of the Southeastern States (Ephemeroptera). Jour. Elisha Mitchell Sci. Soc. 53: 27–86, 1 pl.

Tshernova, O. A. 1928. Beitrag zur Kenntnis der Ephemeropteren des Oka-Bassins. Arb. Biol. Oka-Sta. Murom 5: 113–5, 2 figs.

1948. O novom rode i vide podenok iz basseina Amura (Ephemeroptera, Ametropodidae). Dokladi Akadamii Nauk SSSR, novja serija, 40(8): 1453–5, 1 pl. (New genus and species of Mayfly from Amur-basin.)

Ulmer, G. 1920. Neue Ephemeropteren. Arch. Naturg (1919) 85, A 11: 1–80, 56 figs.

1942. Alte und neue Eintagsfliegen (Ephemeropteren) aus Sud- und Mittelamerika. Stettiner Ent. Zeit. 103: 98–128, 30 figs.

Upholt, W. M. 1936. A new species of mayfly from California (Ephemerida: Baetidae). Pan-Pacific Ent. 12: 120–2, 1 fig.

1937. Two new mayflies from the Pacific Coast. Pan-Pacific Ent. 13: 85–88.

NOTES ON THE PHLEBOTOMUS OF PANAMA XIII. THE VEXATOR GROUP, WITH DESCRIPTIONS OF NEW SPECIES FROM PANAMA AND CALIFORNIA[1]

G. B. FAIRCHILD AND MARSHALL HERTIG
Gorgas Memorial Laboratory, Panama, R. de P.

The species here considered were placed in the subgenus *Brumptomyia*, group *brumpti*, series *vexator* by Fairchild (1955). Of this series, we have selected for discussion only those species whose males bear a definite tuft of setae on the inner base of the coxite. This character is proving to be somewhat artificial, at least in this series, as selection of the species on this basis brings together forms that in other respects appear to be more closely related to species lacking the basal tuft. Thus in *P. durani* Vargas and Diaz Najera the male lacks a basal tuft, while the female has spermathecae and cibarium similar to *P. chiapanensis* Dampf. It is possible in this case, however, that the male and female are not properly associated and that the latter in reality belongs to the *cayennensis* group. The great diversity in wing venation and spermathecal structure also suggests that future study may show that the present grouping based on male characters is rather artificial. We retain it here largely as a matter of convenience.

The geographic distribution of the species treated here is of some interest. All but two of the species occur on the western sides of the continents or in Central America, from California to Peru, the exceptions being *vexator* Coq. in eastern North America and *quinquefer* Dyar in southeastern South America. No less than four species are Nearctic, three others Mexican and five Andean, with three species in Central America including Panama. No species are known from the Amazon basin or the north coast of South America.

The host preferences of several of the species are known. *P. peruensis* Shannon, *pescei* Hertig, and *sanguinarius* n. sp. bite man with avidity, the first two at least entering houses to do so in Peru. *P. hartmanni* n. sp. has also been taken biting in the forest in Panama on a few occasions. *P. peruensis* also appears to bite dogs (Hertig 1942, p. 47), and we have recently taken *P. sanguinarius* in fair numbers biting a horse, although our records show it as only occasionally taken in horse-baited mosquito traps, probably because the latter have seldom been used in its favored habitats. *P. noguchii* Shann. appears to bite only small rodents, mainly *Phyllotis*, and will feed on nothing else in the laboratory (Hertig 1942, p. 40). *P. vexator* has been taken several times feeding on snakes in nature (Shannon 1913) and Hertig (unpublished) has successfully reared the species in the laboratory using snake, turtle, alligator and lizard as the source of blood meals. Nothing positive is known concerning the feeding habits of the other species, though the association of *P. stewarti* Mang. and Galindo with the burrows of the California ground squirrel suggests this rodent as a host. Galindo (personal communication) informs us that he has seen engorged specimens of *stewarti* collected in a field mouse nest in Kern Co., Calif. by T. H. G. Aiken, which would tend to confirm the rodent feeding habits of this species.

The early stages of none of the species have been described in detail, though Hertig has reared *peruensis*, *noguchii*, *vexator*, and more recently, *sanguinarius* from eggs from wild caught females. All the larvae appear to have four caudal setae in the fourth instar.

P. battistinii Hertig, placed in this series provisionally by Fairchild (1955) is omitted, as the male has armed parameres and highly modified setae in the basal tuft of the coxite and is unlikely to be confused with any of the species treated here.

KEY TO FEMALES

1. Cibarium with a comb of about 25 slender teeth. Pharynx armed with irregular spines 2
   Cibarium with 4 or rarely 6 more or less triangular teeth. Pharynx unarmed or minutely spinulose 3
2. Common duct of spermathecae about one-sixth as long as individual ducts, slender ..... **californicus**
   Common duct about one-third as long as individual ducts, rather broad ..... **chiapanensis**
3. Cibarium with 4 large teeth and 2 smaller ones between the lateral large teeth. Wing long and narrow, beta over four-fifths alpha. Spermathecae tubular, with a small oblate head and slender terminal knob ..... **vexator**
   Cibarium with but 4 horizontal teeth 4
4. Beta of wing venation very short, less than one-third alpha. Wing always relatively broad, less than 3.5 times as long as broad 5
   Beta longer, over one-half alpha. Wing generally narrower 8
5. Fourth palpal segment short, less than two-thirds length of third, fifth palpal segment clearly less than half length of third 6
   Fourth palpal segment longer, at least three-fourths length of third; fifth segment at least twice as long as third 7
6. Spermathecae small, deeply annulate, the terminal knob prominent; ducts very slender ..... **hartmanni**
   Spermathecae large, weakly and shallowly annulate, the terminal knob set in a cup-like depression. Ducts thicker ..... **sanguinarius**
7. Spermathecae with distinct hemispherical head and tapering finely annulate body. Chitinous arch broad and diffuse with a median anterior process ..... **peruensis**

[1]Accepted for publication April 5, 1957. Paid paper.

Spermathecae slender, almost tubular, the body not annulate, irregularly wrinkled. Chitinous arch absent or barely visible . . . . . **pescei**

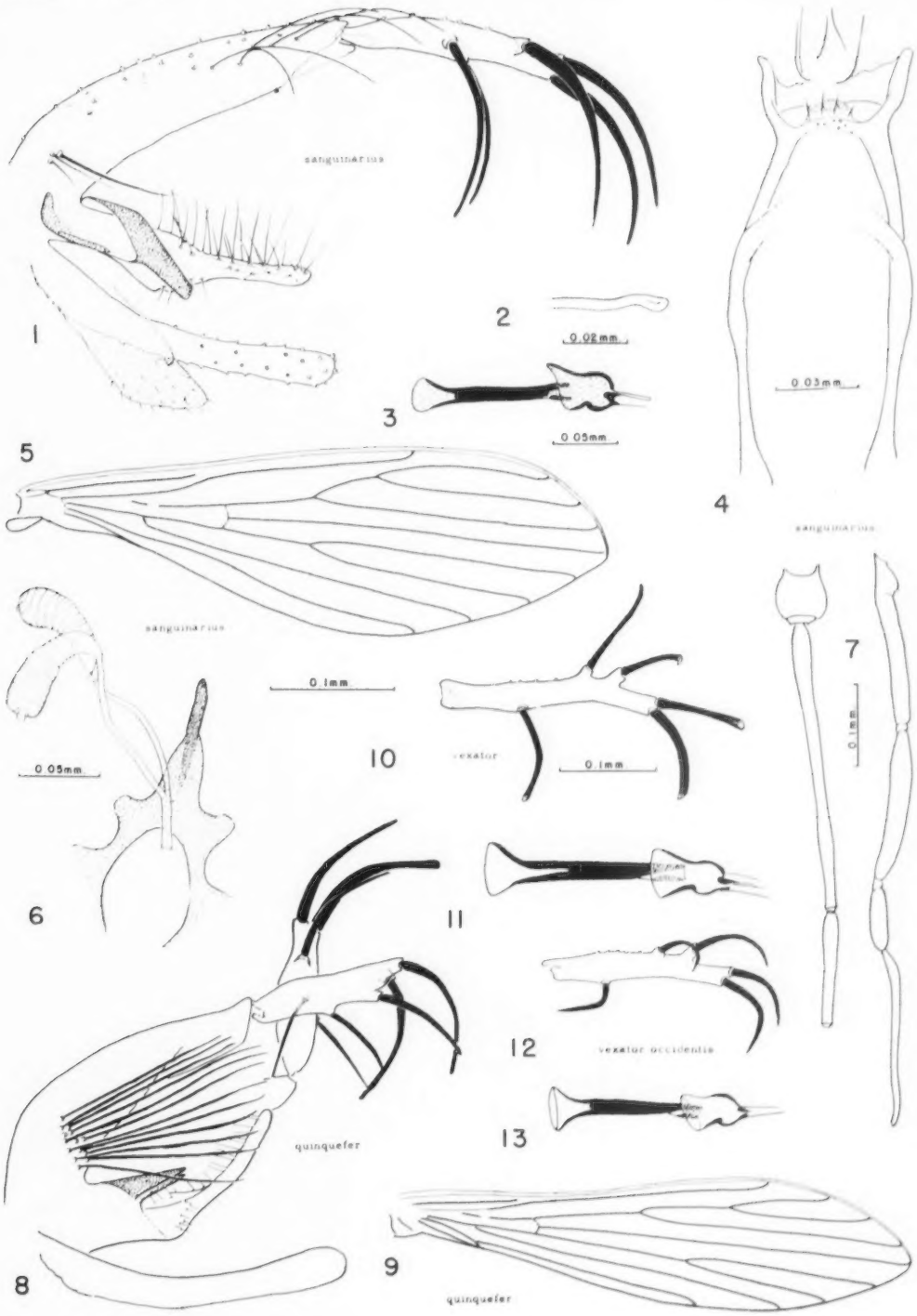
8. Spermathecae with a well-marked hemispherical head and carrot-shaped annulate body, the terminal knob large. Cibarium without chitinous arch . . . . . **stewarti**
Spermathecae otherwise 9
9. Spermathecae small, carrot shaped, rather irregularly annulate with poorly differentiated head . . 10
Spermathecae tubular, with a well marked oblate or spherical head 11
10. Eyes unusually small. Wing narrow, over 3.5 times as long as greatest width; gamma and beta subequal to alpha, delta short, approaching zero. Spermathecae with unusually long and slender terminal knob . . . . . **osornoi**
Eyes of average size. Wing broader, barely over 3 times as long as broad; gamma and beta together about equalling alpha. Delta longer, about one-fourth alpha. Spermathecae with small club-shaped knob . . . . . **noguchii**
11. Spermathecae and ducts over 7 times as long as stem of genital fork, the bodies of spermathecae more slender than ducts, finely annulate; no common duct . . . . . **oppidanus**
Spermathecae and ducts much shorter, less than 4 times length of stem of genital fork 12
12. Spermathecal ducts broad, the body of spermathecae smooth and not differentiated from the ducts. Spermathecae and ducts about 3.5 times as long as stem of genital fork . . . . **vindicator**
Ducts more slender, the tubular, finely and faintly annulate spermathecal bodies more slender than ducts. Spermathecae and ducts hardly twice length of stem of genital fork . . . **vexator occidentis**

KEY TO MALES

1. Wing fairly broad, less than 3.5 times as long as broad, venation with beta very short, less than one-third alpha 2
Wing broad or narrow, venation with beta over one-half alpha 5
2. Basal tuft on coxite of 5 or fewer rather weak and slender setae 4
Basal tuft on coxite of many more than 5 setae. Median spine of style much closer to apex than to basal spines. Alpha about 4 times beta 3
3. Parameres very slender with relatively few and short setae on terminal half only, the basal half narrowed. Lateral lobes straight, clearly longer than coxites. Basal tuft of about 20 broad blade-like spines . . . . . **peruensis**
Parameres stouter, not narrowed at base, their whole dorsal surface beset with longer and more numerous setae. Lateral lobes curved, subequal or but slightly longer than coxites. Basal tuft of fewer and more slender setae . . . . . **pescei**
4. Sperm pump small and slender, the genital filaments from 3.8 to 5 times as long as pump, their tips drawn out into fine points. Aedeagus slender, acute . . . . . **hartmanni**
Sperm pump larger and heavier, the genital filaments from 2.1 to 3.7 times as long as pump, tips blunt and bent. Aedeagus stout, blunt . . . . . **sanguinarius**
5. Basal spines on style unpaired, inserted at markedly different levels. Basal tuft on coxite of 5 or fewer setae. Wing narrow, about 4 times as long as greatest width 6
Basal spines on style paired, inserted at or close to same level 8
6. Genital filaments over 6 times as long as genital pump, the latter with deep "pavillon." Parameres slender, upcurved, slightly clubbed, bearing setae only on apical third . . . . . **oppidanus**
Genital filaments less than 5 times length of pump, the latter with shallow 'pavillon." Parameres shorter, not upcurved, bearing dorsal setae nearly throughout their length 7
7. Genital filaments at least 4.5 times as long as pump. Style long and cylindrical, all but the basal spine inserted well distal of middle of style . . . . . **vexator**
Genital filaments less than 4 times as long as pump. Style shorter and stouter, the next to basal spine inserted close to middle of style . . . . . **vexator occidentis**
8. Basal tuft on coxite of less than 5 setae. Tips of genital filaments hooked. Wing narrow, delta short, less than one-fifth alpha; beta long, subequal to alpha . . . . . **stewarti**
Basal tuft of more numerous setae 9
9. Third antennal segment long, considerably exceeding head height from vertex to base of clypeus . . 10
Third antennal segment shorter, subequal or less than head height 11
10. Wing narrow, at least 4 times as long as wide, alpha much less than twice beta, delta short, less than one-fifth alpha. Eyes small. Basal tuft of short stout setae. Parameres slender, slightly clubbed; lateral lobes clearly longer than coxites . . . . . **noguchii**
Wing broader, less than 3.5 times as long as wide, alpha more than twice beta, delta about one-fourth alpha. Eyes of average size. Basal tuft of very numerous long slender setae. Parameres stouter, the apex less clubbed, somewhat bent downwards; lateral lobes clearly shorter than coxites . . . . . **osornoi**
11. Lateral lobes long and upcurved, clearly longer than coxites. Basal tuft of about 8 slender setae set on a small sclerotized plate. Parameres flattened and widened before the acute apex and with a large setulose lobe dorsally at base . . . . . **vindicator**
Lateral lobes subequal or shorter than coxite. Parameres and basal tuft otherwise 12
12. Basal tuft of about a dozen very long and heavy spine-like setae set in several transverse rows. Parameres slender, upcurved, nearly as long as coxites . . . . . **quinquefer**
Basal tuft of shorter and much more slender setae. Parameres much shorter 13
13. Basal tuft of about a dozen stiff setae closely set on a small eminence; inner aspect of remainder of coxite with but a few rather long setae. Parameres rather evenly tapered to an acute apex . . . . . **californicus**
Basal tuft of about a dozen lax setae in an indefinite transverse patch, hardly distinguishable from the numerous setae clothing inner aspect of whole coxite. Parameres less acutely pointed. Wing broader, less than 4 times as long as broad . . . . . **chiapanensis**

EXPLANATION OF PLATE I

FIGS. 1–7, *P. sanguinarius* n. sp.: fig. 1, male genitalia; fig. 2, tip of genital filament; fig. 3, genital pump, all slide 4262; fig. 4, female cibarium, slide 3944; fig. 5, male wing, slide 3146; fig. 6, spermathecae, drawn in phenol from a specimen from Quebrada Bonita, Colon Prov., Panama, subsequently discarded; fig. 7, female palpi and basal antennal segments, slide 3943. FIGS. 8–9, *P. quinquefer* Dyar: fig. 8, male genitalia, Type no. 41593, U. S. N. M.; fig. 9, male wing, slide 2582 det. as *P. rickardi* C. L. by Mangabeira. FIGS. 10–11, *P. vexator* Coq.: style and genital pump, slides 1562 and 1563. FIGS. 12–13, *P. vexator occidentis* n. subsp.: style and genital pump, style from a specimen collected by Mangabeira and Galindo, pump from slide 3167.


sanguinarius
1
2
0.02mm
3
0.05mm
4
0.03mm
sanguinarius
5
sanguinarius
0.05mm
6
0.1mm
10
vexator
0.1mm
7
0.1mm
11
12
vexator occidentis
13
quinquefer
8
quinquefer
9

Phlebotomus californicus n. sp.

Figs. 20–23.

This species is very similar to *P. chiapanensis* Dampf from Mexico and Central America, differing only in the following respects: Male with basal tuft better defined, of about a dozen stiff setae set on a small eminence, the inner aspect of remainder of coxite with but a few rather long setae (fig. 20). Genital filaments three times length of pump (fig. 23). Paired basal spines of style stouter, at middle of style, the single median spine halfway between them and apex. Female with cibarium as in *chiapanensis*, but spermathecae with common duct more slender and much shorter.

Holotype male, slide 3165, Fort Yuma, Imperial Co., Calif., 28 October 1948, light trap, R. Coleman coll. Allotype female, slide 3170. Same data as holotype. Paratype male, slide 3166. Same data as holotype.

In addition, we have a female, slide 3169, Ukiah, Mendocino Co., Calif., 29 July 1948, W. W. Wirth coll. which may be this species, but since the head is missing and the spermathecae collapsed, certainty is impossible.

Phlebotomus chiapanensis Dampf

1947, Medicina, Mexico, 27(530): 3–7, figs. 1–6 (♀; Chiapa de Corzo, Chiapas, Mexico). Fairchild and Hertig, 1948, Ann. Ent. Soc. Amer., 41(4): 467, Pl. 2, figs. 1–6 (♂, ♀; Panama and Costa Rica). Vargas and Diaz Najera, 1952, Rev. Invest. Clin., Mexico, 4(1): 50 (Guerrero, Mexico).

This species has been adequately figured and described by Dampf (1947) and ourselves (1948). We have material from about a dozen localities on the Pacific coast of Panama, from Barranca, Costa Rica and from La Libertad, El Salvador, 14 June 1953. It has been taken in crevices in masonry most frequently, occasionally in tree buttresses and animal burrows, and in light traps, but is not very abundant. Specimens are at hand from nearly every month of the year.

Phlebotomus hartmanni n. sp

Figs. 14–19, 25.

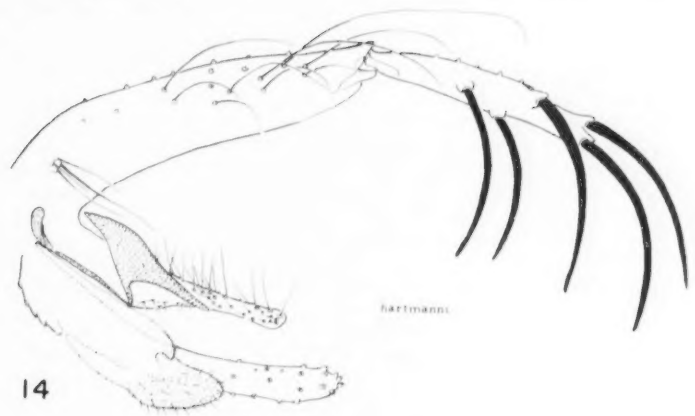
Male. Wing length 1.8 to 2.1 mm., venation as figured. Mesonotum, pleura and abdomen lightly infuscated. Abdominal setae erect. Postspiracular setae 10, lower mesanepisternals 5, the latter slender, not ligulate. Proboscis a little less than head height, the eyes large. Palpi with segments II and III subequal, IV less than two-thirds of either, V longer than any preceding segment but shorter than any two. Third antennal segment long, extending to end of third palpal segment and beyond tip of proboscis on intact head. Newstead's scales scattered over middle half of ventral surface of third palpal segment. Ascoids slender, simple, much shorter than their respective segments, present on all but the terminal segment of antenna. Wing as figured. Cibarium slender, without teeth and with but a faint indication of chitinous arch. Pharynx slender, unarmed. Genitalia as figured, the filaments slender, about 3 times length of pump, their apices simple, very slender.

Female. Wing length 1.79 to 2.3 mm., venation as in male. Color and vestiture as in male. Proboscis considerably exceeding head height, eyes relatively smaller. Palpi with segments II and III proportionally somewhat longer, IV hardly one-half either, V equal or less than III. Third antennal segment reaching to middle of palp III, failing to reach end of proboscis on intact head. Newstead's scales more numerous than in male, on distal two-thirds of palp III. Ascoids longer than in male, nearly as long as their respective segments, present on all but terminal segment. Wing as in male. Cibarium as figured. Pharynx broad and well-sclerotized, unarmed, its posterior end with numerous fine ridges. Spermathecae and genital fork as figured. A few setae on sides of eighth tergite, setae on dorsum of ninth tergite narrowly ligulate, anterior lateral setae on seventh sternite reduced to short acute spines.

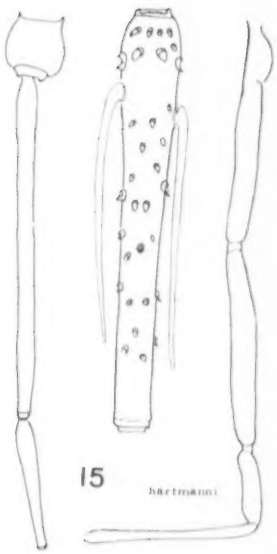
Holotype male, slide 3997, Cerro Campana, Panama Prov., Panama, 24 April 1952, light trap, F. Blanton coll. Allotype female, slide 2904, same data as holotype. Paratypes, 11 ♂ 5 ♀, same data as holotype; 8 ♀, Cerro Campana, Panama Prov., Panama, Yellow Fever Sta. C, 10 February 1951, Shannon trap at light, Hertig, Galindo and Fairchild colls.; 2 ♀, Camp Piña, C. Z., 7 and 9 May 1955, in mosquito light trap in forest canopy, G. Field coll.; 1 ♀, Ft. Sherman Reservation, S-8 Road, C. Z., 31 March 1955, light trap, G. Field coll.; 1 ♀, Almirante, Bocas del Toro Prov., Panama, 11 December 1951, biting man at night, Mejia coll; 1 ♀, Cerro Sta. Rita, Colon Prov., Panama, 6 May 1948, in animal burrow, Fairchild coll. In addition to the above slide-mounted material, we have the following specimens preserved in alcohol after treatment with KOH. 1 ♂, Almirante, 3 June 1952, taken at night in tree tops; 1♂, Cerro Campana, 16 August 1954, light trap; 4 ♂ 2 ♀, Cerro Campana, 18 August 1954, light trap; 3 ♀, Cerro Campana, 19 September 1952, light trap;

EXPLANATION OF PLATE II

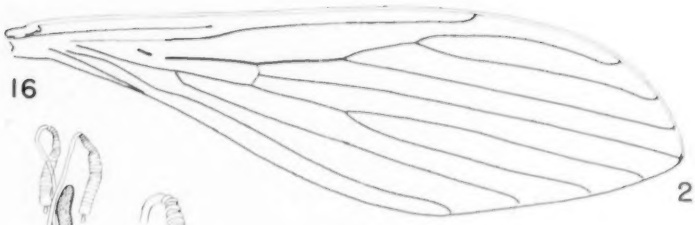
FIGS. 14–19 and 25, *P. hartmanni* n. sp.: fig. 14, male genitalia, slide 3997; fig. 15, female palpi, basal antennal segments and seventh antennal segment showing ascoids, slide 2907; fig. 16, male wing, slide 3997; fig. 17, spermathecae, slide 2904, with single spermatheca enlarged from slide 4009; fig. 18, tip of genital filament, slide 3995; fig. 19, genital pump, slide 3994; fig. 25, female cibarium, slide 2907. FIGS. 20–23, *P. californicus* n. sp.: fig. 20, male genitalia, slide 3166; fig. 21, seventh antennal segment showing ascoids, slide 3170; fig. 22, basal antennal segments and palpi, slide 3170; fig. 23, genital pump, slide 3165. FIG. 24, *P. stewarti* Mangabeira and Galindo, paratype, genital pump.



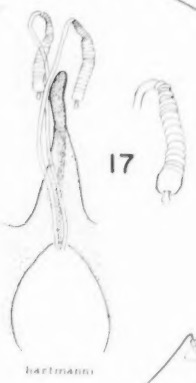
14



15



16



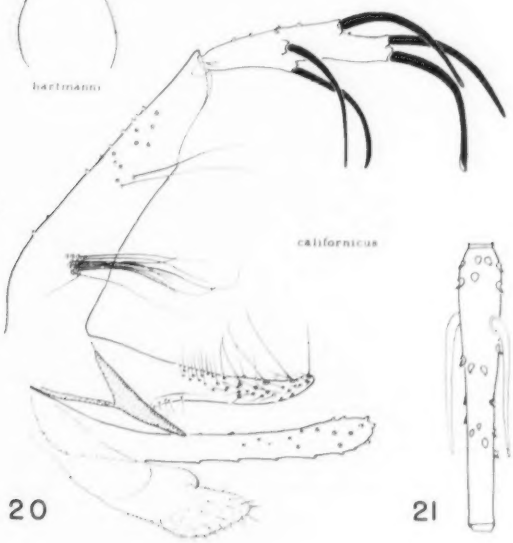
17

18

19

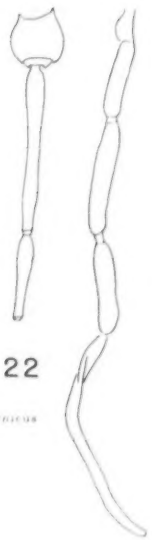
24

23

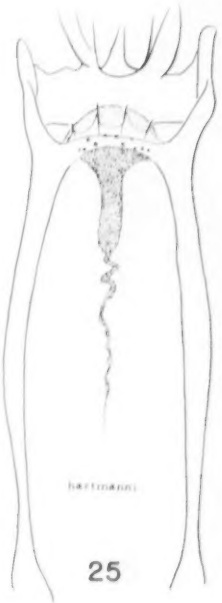


20

21



22



25

1 ♂, Cerro Campana, 17 August 1954, light trap; 1 ♀, Camp Piña, C. Z., 10 May 1955, light trap; 1 ♀, Camp Piña, 13 July 1955, light trap.

The collections from Cerro Campana were made at elevations of 2000 feet or more, in wet montane forest, those from the other localities in heavy wet Atlantic Coast forest. The species is named in honor of Sr. Ratibor Hartmann, our assistant, whose skill in mounting *Phlebotomus* has greatly facilitated our work.

Phlebotomus imperatrix Alexander

1944, Rev. Ent., 15(3): 316–317, fig. 3 (♀; Huacapistana, Tarma, Dept. Junin, Peru). Dampf, 1947, Rev. Ent. 18(3): 305–316, figs. 1–8 (Redescription of type).

We have seen no specimens referable to this species. From Dampf's careful redescription of the unique type, it is evident that it is closely related to *peruensis* and *pescei*, and the male would be expected to fall in the group under discussion. It appears to differ from these two species chiefly in the proportions of the palpal segments. In *imperatrix* the fourth palpal segment is less than half the length of either the second or third segments, while in *peruensis* and *pescei* it is always at least two-thirds their lengths and usually longer. The fifth palpal segment is also both actually and relatively shorter in *imperatrix*. There are also some minor differences in the internal head structures, whose validity is difficult to assess on the basis of available material. The type locality is considerably removed from the known distribution of *peruensis* and *pescei*, and at a considerably lower elevation. The similarity of *imperatrix* to *sanguinarius* n. sp. and *hartmanni* n. sp. is even closer, and except for the greater size of *imperatrix*, we are unable to point out characters which will separate them. Final placement of the species must continue to await further material.

Phlebotomus noguchii Shannon

Figs. 30, 34.

1929, Jour. Exp. Med., 49(6): 996 (June). 1929, Amer. Jour. Hyg., 10(1): 84–85, figs. 1, 3, 6–8 (♂; ♀; Verrugas Canyon, Rimac Valley, Peru). Hertig, 1938, Amer. Jour. Hyg., 28(3): 463–468, figs. 2, 4, 6. 1943, Amer. Jour. Hyg., 37(3): 249, fig. 15. Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 214–215 (Full references). Rozeboom, 1947, Proc. Ent. Soc. Washington, 49(7): 181, figs. 6–8.

We have little to add to previous descriptions of the species, except for giving a figure of the spermathecae (fig. 30) and genital pump (fig. 34). We have seen material only from *Peru*: Cañon del Pato, Ancash, 21 July 1945, 2 ♂; Tornamesa to Matucana, Rimac Valley, Lima, April 1951, in caves, A. Herrer coll., 8 ♂, 3 ♀.

Phlebotomus oppidanus Dampf

Figs. 26–29.

1944, Rev. Soc. Mexicana Hist. Nat., 5(3–4): 247–248, figs. 1–8, 14. (♀; San Jacinto, Mexico, D.F.). Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 215.

A series of 14 ♂ 12 ♀ from a single locality enables us to describe and figure the hitherto unknown male of this species, which proves to be similar to, but clearly distinct from *vexator*.

Male. Wing length 1.7–2.0 mm. Mesonotum moderately infuscated, pleura pale. Abdominal setae apparently erect. Postspiracular setae 3 to 10, lower mesanepisternals 3 to 5, at least the latter narrowly ligulate. Proboscis not equaling head height. Palpi with segments II, III and IV subequal, V long, equal to or greater than any two preceding. Third antennal segment long, at least twice the fourth segment and reaching middle of third palpal segment and slightly beyond tip of proboscis on intact head. Newstead's scales in a dense cluster on inner aspect of third palpal segment somewhat proximal to middle. Ascoids slender, without posterior prolongation, not reaching ends of their respective segments, present on all but terminal segment. Wings as figured (fig. 28). Cibarium slender, without teeth and with a very faint chitinous arch. Pharynx slender, unarmed. Genitalia as figured (fig. 26), the filaments over 6 times length of pump (fig. 29), their apices drawn out into a slender point (fig. 27).

Description based on 14 ♂ taken in rock crevices and a small cave about 1 km. east of Gruta de Garcia, 20 miles N. W. of Monterrey, Nuevo Leon, Mexico, 9 and 11 September 1955, H. Trapido and P. Galindo colls.

Phlebotomus osornoi Ristorcelli and Van Ty

1941, Ann. Parasit. Hum. Comp., 18: 260–263, figs. 4, 5 (♀; Valle de Capuli, Prov. Nariño, Colombia). Rozeboom, 1947, Proc. Ent. Soc. Washington, 49(7):177–182, figs. 1–5 (♂, ♀; Tuquerres, Colombia).

We have not seen this species, but from the descriptions it appears to be related to *P. peruensis*, *noguchii* and *quinquefer*, from all of which it can be separated in the male by the shape of the parameres, and in the female by the elongate knob on the apex of the spermathecae.

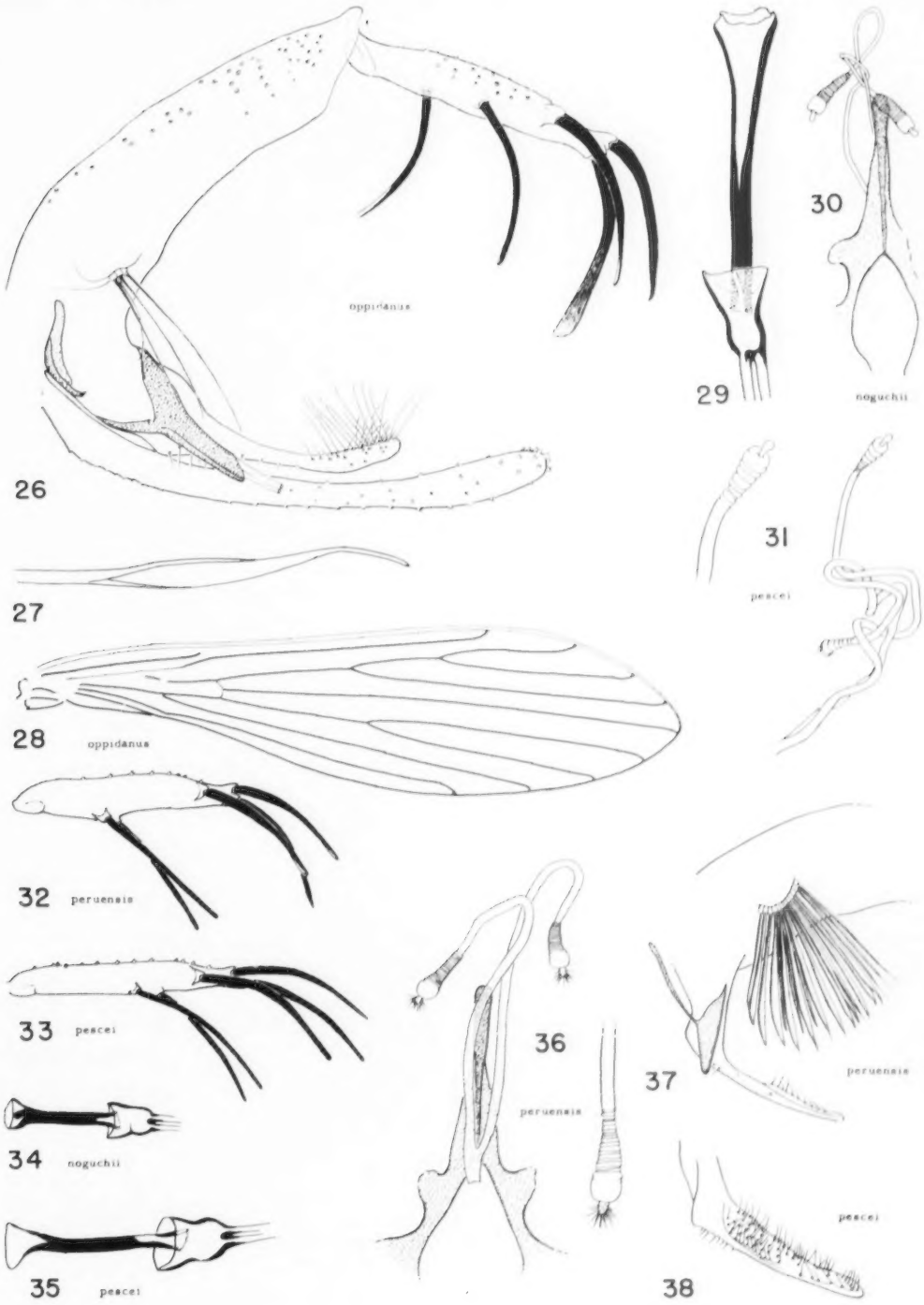
Phlebotomus peruensis Shannon

Figs. 32, 36, 37.

1929, Jour. Expt. Med., 49(6): 996 (♂, ♀; Matucana, Peru) (June). Shannon, 1929, Amer. Jour. Hyg., 10(1): 85–87, Pl. I, figs. 4, 10; Pl. II, figs. 5, 6. (♂, ♀;

EXPLANATION OF PLATE III

FIGS. 26–29, *P. oppidanus* Dampf: fig. 26, male genitalia, slide 4894; fig. 27, tip of genital filament, slide 4897; fig. 28, male wing, slide 4897; fig. 29, genital pump, slide 4884. FIGS. 30, 34, *P. noguchii* Shannon: fig. 30, spermathecae, slide 3144; fig. 34, genital pump, slide 3134. FIGS. 31, 33, 35, 38, *P. pescei* Hertig: fig. 31, spermathecae, slide 1158; fig. 33, style, slide 1156; fig. 35, genital pump, unnumbered specimen from Huancayo, Peru; fig. 38, paramere, slide 1156. FIGS. 32, 36, 37, *P. peruensis* Shannon: fig. 32, style, slide 3138; fig. 36, spermathecae, slides 3139 left, and 1099 right; fig. 37, paramere and base of coxite, composite of slides 855 and 856.


oppidanus
26
29
30
noguchii
31
pescei
27
28
oppidanus
32
peruensis
33
pescei
34
noguchii
35
pescei
36
peruensis
37
peruensis
pescei
38

Matucana, Peru) (July). Hertig, 1943, Amer. Jour. Hyg., 37(3): 249–250, fig. 16 (♀; description of head). Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 217 (Full references).

There is little to add to previous descriptions of this species, except to give figures of the spermathecae (fig. 36), the basal tuft of coxite (fig. 37) and style (fig. 32). Aside from material from various localities in the Rimac Valley above Lima, Peru, we have specimens from the following localities, all in Peru: 2 ♂, Huancalle, Dept. Cuzco; 1 ♂, Cuzco, 21 November 1947, in rocky gully 8 km. S. of city, M. and A. Hertig colls.; 1 ♂, Chancos, Dept. Ancash, 22 July 1945, Hertig and A. Herrer colls.

Phlebotomus pescei Hertig

Figs. 31, 33, 35, 38.

1943, Amer. J. Hyg., 37(3): 248–249, figs. 10–14 (♀; Hacienda Pincos, Pincos Valley, Andahuaylas, Dept. Apurimac, Peru). Dampf, 1947, Rev. Ent., 18(3): 306–307. Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 218.

This species is exceedingly close to *P. peruensis* Shann. We are unable to point out characters other than the spermathecae and male genitalia which will separate the two with certainty; the characters of the cibarium used by Hertig being somewhat variable.

Male. Wing length 2.3–3.0 mm. Mesonotum moderately infuscated, pleura paler. Abdominal setae apparently erect. Postspiracular setae about 8, lower mesanepisternals 3. Proboscis considerably exceeding head height. Palpi with segments II and III subequal, IV shorter, V subequal to II plus III. Third antennal segment long, reaching on intact head to middle of palp III and to end of proboscis, about twice as long as fourth segment. Newstead's scales scattered along middle third of third palpal segment. Ascoids not visible on available material. Wing as figured by Hertig, with beta very short, as in *peruensis*. Cibarium without teeth, the chitinous arch apparent only at sides. Pharynx slender, unarmed. Genitalia as figured (fig. 33), the filaments about 3.5 times length of pump, their tips simple.

Description based on the following material from *Peru*: 4 ♂, Rio Cunas, 9 mi. W. of Huancayo, Dept. Junin, 11,000 ft. elev., 25 December 1943, in shallow cave, Hertig and Fairchild colls.; 2 ♂, Pincha, Huancayo, 13 August 1945, in house, Hertig coll.; 1 ♂, Las Huatatas, 3 km. from Ayacucho, Dept. Ayacucho, December 1944, in mill cave, V. Ayulo coll.

Female similar to male in external characters. Cibarium and head structures as figured by Hertig. Spermathecae (fig. 31) similar to *peruensis*, but without the fine annulations of the latter. We have studied females from the following localities in *Peru*: 1 ♀, Pincos, Dept. Andahuaylas, 10–11 May 1940, H. Pesce coll. (cotype); 1 ♀, Dept. Andahuaylas, May 1940, H. Pesce coll. (Probably a cotype); 4 ♀, Rio Cunas, Huancayo, Dept. Junin, 25 December 1943, in shallow caves, Hertig and Fairchild colls.; 1 ♀, Rio Pampas bridge, Dept. Ayacucho, December 1944, Ayulo coll.; 5 ♀, Ollantaytambo, Dept. Cuzco, 2790 metres elev., 18 November 1947, in railroad station, M. and A. Hertig colls.; 4 ♀, Pisac, Dept. Cuzco, more or less 3000 metres elev., 20 November 1947, in chapel, M. and A. Hertig colls.

Phlebotomus quinquefer Dyar

Figs. 8–9.

Phlebotomus (*Brumptomyia*) *quinquefer* Dyar, 1929, Amer. Jour. Hyg., 10(1): 114, figs. 1–2. (♂; Iguazu Falls, Misiones, Argentina.) Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 220. (Full references.)

Phlebotomus rickardi Costa Lima, 1936, Rev. Med. Cir. Brasil, 44: 288, (♂; Crato, Ceara, Brasil). Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 220. (Full references.) Barretto and Pessoa, 1946, Livro de Homenagem a R. F. d'Almeida, No. 7, p. 88. (São João, Espirito Santo, Brasil.) Barretto, 1950, Arq. Hyg. Saude Publica, S. Paulo, 15(46): 225. (Ceara and Espirito Santo, Brasil.) (New synonymy.)

We have examined the holotype of *P. quinquefer* Dyar in the USNM. The specimen is much folded and distorted, but one of us (M.H.) was enabled to make a camera lucida sketch of the genitalia, which is reproduced here (fig. 8). The basal tuft is shown as it if was on the external surface of the coxite. It is actually on the inner aspect, but drawn thus for clarity. Dyar's figure was apparently a free-hand sketch, and bears only a vague general resemblance to the specimen, which accounts for the species not having been subsequently recognized. Dyar made no mention of the wings in his description and we made no notes when examining the Type. The ascoids are short, about half the length of their respective segments, and the eyes are small.

Through the courtesy of Dr. M. P. Barretto we have recently received a mounted male of *P. rickardi* C. L. labelled "Brasil, Esp. Santo, Vila Alegre, em luz, Zikan coll. s.d." The genitalia agree closely with our drawing of the type of *quinquefer*. In this specimen the filaments are somewhat more than 3 times as long as the pump, apparently with unmodified tips. The fifth palpal segment appears to be slightly shorter than the second and third together, while the fourth segment is about three-fourths as long as the third. The first flagellar segment of the antenna is shorter than the first three palpal segments, and about twice as long as the second flagellar segment. The ascoids are apparently simple and short, though difficult to see on the unstained specimen. The proboscis is much shorter than head height. The wing is long and narrow, with alpha only slightly longer than beta and delta short, as shown (fig. 9).

Phlebotomus sanguinarius n. sp.

Figs. 1–7.

Male. Wing length 1.7 to 2.0 mm., venation as

figured. Head and mesonotum rather heavily infuscated, pleura, abdomen and legs dusky. Abdominal setae partly recumbent. Post spiracular setae 11 to 15, slender; mesanepisternals 4, narrowly ligulate. Proboscis a little less than head height, the eyes large. Palpi with segments II and III subequal, IV about half length of either, V longer than any preceding, but not as long as any two preceding segments. Third antennal segment long, reaching to middle of fourth palpal segment and well beyond tip of proboscis on intact head. Ascoids simple, short, hardly half length of their respective segments, present on all but terminal segment. Cibarium slender, unarmed, without chitinous arch. Pharynx slender, pigmented, unarmed. Genitalia as figured, the pump rather heavy and filaments stout, from 2.1 to 3.7 times length of pump, their tips with a slight kink before the blunt apex.

Female. Wing length 1.9 to 2.2 mm., venation as in male. Head, mesonotum, legs and abdomen rather strongly infuscated, pleura paler. Pleural setae as in male. Proboscis considerably longer than head height, eyes medium. Palpi with segment III generally a little longer than II, IV usually less than half III, V subequal to III. Third antennal segment relatively though not actually shorter than in male, reaching to middle of third palpal segment but not to end of proboscis on intact head. Ascoids simple, longer than in male, though not attaining ends of their respective segments, present on all but terminal segment. Cibarium as figured. Pharynx broad, well sclerotized and pigmented, unarmed. Spermathecae and genital fork as figured. Dorsum of ninth tergite with narrowly ligulate curved setae, sides of eighth tergite with a group of setae, anterolateral setae of seventh sternite short and spine-like.

Holotype male, slide 4262, Almirante, Bocas del Toro Prov., Panama, light trap, 28 October 1952. Allotype female, slide 3943, Almirante, biting man at night in tree tops, 26 March 1952.

Paratypes, 23 ♂, 46 ♀ mounted on slides, as follows: *Panama:* 2 ♀, slides 66, 68, Chiriqui Pt., Bocas Prov., 1 April 1943, biting man, Marucci and Wood colls.; 2 ♀, slides 361, 362, Pinogana, Darien Prov., 20 February 1943, biting man, Marucci and Wood colls.; 5 ♀, slides 372, 373, 428, 885, 886, El Valle, Cocle Prov., 31 March 1945 and 12 April 1947, biting man, C. D. Michener and H. Trapido colls.; 2 ♀, slides 864, 865, Santa Fe, Veraguas Prov., 20 March 1947, biting man, Fairchild and Galindo colls.; 3 ♀, slides 1383, 1528, 1529, Gatuncillo, Chagres River, 1 February 1945 and 15–16 March 1945, in horse baited stable trap, H. Trapido coll.; 2 ♂ 2 ♀, slides 989, 990, 1001, 1457, Rio Pequeni, Madden Lake area, 28 September 1947 and 26 March 1949, ♂♂ in hole in bank, ♀♀ biting man and in rock crevice, H. Trapido and P. Galindo colls.; 2 ♀, slides 666, 3390, Cruces Trail, C. Z., Forest Reserve, 27 September 1945 and 29 July 1951, in hollow tree with bats and in tree buttresses, M. Hertig coll.; 1 ♂, slide 788, Robalo, Bocas Prov., 30 January 1947, in buttress, P. Galindo coll.; 1 ♂, slide 1328, Rio Puente, Madden Lake area, 11 November 1948, in rock crevices, P. Galindo coll.; 1 ♀, slide 1597, Cacique, Colon Prov., 19 September 1949, biting man in daytime in forest, R. Hartmann coll.; 1 ♀, slide 1742, Rio del Medio, Colon Prov., 14 October 1949, biting man in daytime in forest, R. Hartmann coll.; 1 ♀, Juan Mina, C. Z., slide 2061, 20 December 1949, in light trap, H. Trapido coll.; 4 ♂, slides 3641, 3819, 3820, 4264, Mojinga Swamp, Ft. Sherman reservation. C. Z., 5 September and 4 December 1951, 29 October 1952, in light traps, F. S. Blanton coll.; 6 ♂ 1 ♀, slides 2111, 2112, 2114, 2125, 2128, 2129, Coiba Island, El Maria and ridge back of Penal Colony, 11, 12, 16, 17 January 1950, in tree buttresses, R. Hartmann coll.; 3 ♂ 2 ♀, slides 2364, 2365, 2381, 2382, 2403, La Victoria, Cerro Jefe, Panama Prov., 29 August, 1–2 September 1950, in Shannon trap at light, M. Hertig and P. Galindo colls.; 15 ♀, slides 2305, 2551–2565, Cerro Campana, Panama Prov., 9 August 1950, biting man at ground level, and 24 August 1950, in Shannon trap at light, Hertig and Fairchild colls.; 2 ♂ 5 ♀, slides 4262, 3146, 3185, 3197, 3198, 3943, 3944, Almirante, Bocas Prov., 26 March, 16, 23, 31 May, 28 October 1952, in buttresses, at light, and biting man in tree tops, A. Quinoñez, W. Hils and H. Trapido colls. *Costa Rica:* 3 ♂, slides 2946 to 2948, Turrialba, 12 April 1951, in buttresses and crevices in boulders, P. Galindo and R. Rosabal coll. *Honduras:* 3 ♀, slides 4376, 4377, 4415, Lancetilla Valley, Tela, 23 September, 28 October, 30 December 1953, biting in forest at night, W. Hils, coll.

In addition we have 1 ♂, 9 ♀, slides 2915, 2920, 2921, 2926, 2931, 2937, 2939, 2940, 2950, Palo Santo, Chiriqui Prov., 2–3 March 1951, in Shannon trap at light, and 14 March 1951, biting man in house, R. Hartmann coll. which are excluded from the Paratype series because of their markedly greater size, wing length 2.7–3.0 mm., although we can detect no other differences from the type series.

Of determined, but unmounted material we have close to 900 specimens, less than 10% of which are males. The species bites man avidly in the forest at night and occasionally during the day, both at ground level and in the tree tops. It also bites horses and enters horse-baited stable traps in small numbers. We have taken it in about 40 localities and in every month of the year, though it appears to be very much more abundant in areas of forest with heavy rainfall, being rarely taken on the drier Pacific side of the Isthmus or in open areas cleared of forest. It is not taken in appreciable numbers in the usual daytime resting places, even in localities where it has been taken biting in abundance. We have reared both sexes in the laboratory from eggs secured from wild caught females.

Phlebotomus stewarti Mangabeira and Galindo

Fig. 24.

1944, Amer. Jour. Hyg., 40(2): 185–188, figs. 19–21 (♂, ♀; Alameda and Contra Costa Counties, Calif.). Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 225.

Through the courtesy of Dr. L. W. Quate we have been able to examine 1 ♀, 7 ♂ paratypes of this species from Calaveras Creek, Marsh Creek and Livermore, Calif., and 2 ♂, 2 ♀ from Caliente Creek, Kern Co., Calif., 18 May 1941, Bohart and MacSwain colls. The females are fragmentary but probably belong to this species. We have also seen 1 ♂ labelled "Marsh Creek, Calif. XI–21–43 Galindo and Mangabeira colls.", probably also a paratype but not so labelled, deposited in the Gorgas Memorial Laboratory collections by Dr. Galindo. We give here a figure of the genital pump (fig. 24) of this specimen for comparison with *P. californicus* n. sp.

Phlebotomus vexator Coquillett

Figs. 10–11.

1907, Ent. News, 18: 102 (♂, ♀; Plummer's Island, Md.). Shannon, 1913, Proc. Ent. Soc. Washington, 15(4): 165–167 (Paris, Va.). Hall, 1936, Proc. Ent. Soc. Washington, 38(2): 29 (Ansley, La.). Dampf, 1947, Rev. Soc. Mex. Hist. Nat., 8(1–4): 205–212, Plates 26, 27. Addis, 1945, Trans. Amer. Microscop. Soc., 64(4): 331. Barretto, 1947, Arq. Zool. Est. S. Paulo, 5(4): 229 (Full references).

We have studied a series of 2 ♂ 6 ♀ from Plummer's Island, Md., 6 August 1949, M. Hertig coll. The excellent figures of both sexes given by Dampf (1947) can hardly be improved upon, and we add only figures of the style (fig. 10) and genital pump (fig. 11) for comparison with the California subspecies. Specimens reported as *vexator* from California by Mangabeira and Galindo (1944) appear to us to be distinct on the basis of minor but apparently constant characters, and are discussed below.

Phlebotomus vexator occidentis n. subsp.

Figs. 12–13.

Phlebotomus vexator, Mangabeira and Galindo, 1944, Amer. Jour. Hyg., 40(2): 183–185, figs. 1–8, 22–26 (♂, ♀; Contra Costa and Alameda Counties, Calif.). Addis, 1945, Trans. Amer. Microscop. Soc., 64(4): figs. 5, 12

This subspecies is very similar to *vexator* Coq., differing in the following respects: Male with genital filaments shorter, less than 4 times length of pump (fig. 13); style (fig. 12) shorter and stouter, the two subapical spines farther apart and the most basal one of this pair closer to the basal spine than in *vexator*. Basal tuft of coxite of 4 setae. Female with spermathecae shorter, more slender, less than twice as long as stem of genital fork. Cibarium narrower, with but 4 horizontal teeth, lacking the sublateral shorter teeth found in *vexator*.

Holotype male, slide 3167, Alturas trap station, Modoc Co., Calif., August 1948, light trap, R. Coleman coll. Allotype female, slide 3164, Topaz Lake, Mono Co., Calif., 1 August 1948, light trap, R. Coleman coll. Paratypes, 2♂ 3 ♀, Marsh Creek, Contra Costa Co., Calif., 19 and 25 September 1948, Galindo, Mangabeira and Reeves coll.; 1♂ 4 ♀ same data as allotype; 1 ♀, same data as holotype; 1 ♀, Strawberry Canyon, Alameda Co., Calif., November 1948, light trap, W. W. Wirth coll.; 1 ♀, Fillmore, Ventura Co., Calif., 6 June 1948, light trap, R. Coleman coll.; 1 ♀, Livermore, Calif., 19 October 1943, in *Citellus beecheyi* burrow, P. Galindo and O. Mangabeira colls. In addition, we have another specimen with same data as the last paratype which lacks both head and spermathecae, but is probably this species. Finally, we have examined, through the courtesy of Dr. L. W. Quate, a series of 18 ♂, 50 ♀, Hooper estate, Woodside, California, collected by T. N. Lauret, 1 and 15 June, 3 and 22 August and 5, 7 and 9 September 1956. These specimens were identified in phenol and stored unmounted in alcohol. Holotype and allotype to be deposited in USNM, paratypes in coll. L. W. Quate and in the Gorgas Memorial Laboratory.

The record of *Phlebotomus* from Modoc Co. extends the range of the genus considerably farther north in the New World, to beyond 41° N. latitude. The previous northernmost record appears to have been Plummer's Island, Md., at about 39° N.

Phlebotomus vindicator Dampf

1944, Rev. Soc. Mex. Hist. Nat. 5: 248 (♀, Chapultepec, D. F., and Cuautla, Morelos, Mexico); Rev. Soc. Mex. Hist. Nat. 8(1–4): 205 (♂). Vargas and Diaz Najera, 1953, Rev. Inst. Salub. Enferm. Trop., 13(4): 313.

We have a single female from Cañon de Lobos, between Cuernavaca and Yautepec, Morelos, Mexico, 4100 ft. elev., 20 Sept. 1955, taken in a small cave, Galindo and Trapido colls. We have nothing to add to Dampf's excellent description.

REFERENCES CITED

Dampf, A. 1947. Notas sobre flebotomidos mexicanos. III. Un nuevo flebotomo (*P. chiapanensis*) aparentemente antropofilo. Medicina, Mexico, 27(530): 3–7, 6 figs.

1947. Notas sobre flebotomidos mexicanos. IV. El macho de *Phlebotomus vindicator* Dampf. Rev. Soc. Mex. Hist. Nat., 8(1–4): 205–213, Plates 24–27.

Fairchild, G. B. 1955. The relationships and classification of the Phlebotominae (Diptera, Psychodidae). Ann. Ent. Soc. America 48(3): 182–96, 19 figs.

Fairchild, G. B., and **Marshall Hertig.** 1948. Notes on the Phlebotomus of Panama. IV. *P. atroclavatus* Knab, *P. cayennensis* Floch and Abonnenc, *P. chiapanensis* Dampf and some related forms from the West Indies and Mexico. Ann. Ent. Soc. America 41(4): 455–67, Plates 1–5.

Hertig, Marshall. 1942. Phlebotomus and Carrion's Disease. Amer. Jour. Trop. Med., Suppl., 22(5) III, Field studies on Phlebotomus, pp. 23–60, Plates 1–6.

Mangabeira, O., and **P. Galindo.** 1944. The genus *Flebotomus* in California. Amer. Jour. Hyg., 40(2): 182–94, Plates 1–3.

Shannon, R. C. 1913. Feeding habits of *Phlebotomus vexator* Coq. Proc. Ent. Soc. Wash. 15(4): 165–7.

A STUDY OF THE HOST DISTRIBUTION AND SOME RELATIONSHIPS OF MALLOPHAGA PARASITIC ON BIRDS OF THE ORDER TINAMIFORMES PART I[1]

RONALD A. WARD

Department of Biology, Gonzaga University, Spokane, Washington

INTRODUCTION

Data derived from comparative anatomy and embryology are often inadequate for expressing the relationships between groups of animals. In some groups of animals, particularly the birds and mammals, the use of ectoparasites has become a supplementary tool. The students of ectoparasites, especially the Mallophaga, Anoplura, Siphonaptera and Analgesid feather mites, can often provide exact data on hitherto obscured relationships. The basic assumptions in an analysis of this type have been summarized by Rothschild and Clay (1952) as follows:

(1) At an early stage of its evolution, a host group became parasitized by a group of parasites.

(2) With the speciation and divergence of the host into different environments, changes occurred in the form, physiology and integument of the host.

(3) The parasite because of its intimate relation to the host had to adapt itself to the above changes, which became reflected in its structure.

(4) The evolution of the parasite is slower and less drastic because environmental changes are of less magnitude for the parasite than for the host.

An investigation was undertaken to determine the correspondence between host and parasite both at the generic and higher levels, and the lower categories, particularly the species. Some host-parasite relations have been analyzed with the aid of statistical techniques, and these will be treated in Part II of this study. The Mallophaga parasitic on the bird order Tinamiformes were utilized in this investigation. Certain advantages were achieved by the use of these two groups. The host order is ideal because of the relatively small number of species grouped into nine genera. A workable classification of the tinamous was available (von Boettischer, 1934) as a check with the observations on the Mallophaga. An excellent collection of tinamou skins was available which could be examined for Mallophaga. Contrary to the situation for many avian Mallophaga, virtually all the species living on tinamous could be identified from the literature. Much of the descriptive work had been completed by Carriker (1936, 1944, 1946, 1953a, 1953b, 1954, 1955a, and 1955b), Clay (1937 and 1943), Guimarães (1936, 1942a, 1942b, 1942c, 1943, 1944a, 1944b, 1946, 1947a, 1947b, 1948, 1950a, 1950b, and 1953), Guimarães and Lane (1937), and von Kéler (1938, 1939a, and 1939b). Species described prior to 1900 have all been redescribed.

MATERIALS AND METHODS

When a bird is killed, the Mallophaga fauna living in the feathers dies within a few hours. Observations of many workers show that the Ischnoceran population usually remains on the skin after death of the host while the Amblycera have a tendency to wander. Some lice are lost during preparation of the bird skin but a sufficient number remain to make it profitable to examine the study skin for specimens. As many as 12 species of Ischnocera have been observed from a single subspecies of tinamou although a maximum of only nine species have been recovered from a single bird skin. In contrast, only two Amblycerans ever occur on these birds and are apparently scarce.

Each skin of a tinamou in the collection of the Chicago Natural History Museum was thoroughly examined three times for Mallophaga. A total of 1500 skins were examined. The technique involved a careful ruffling of the feathers of the study skin over a large sheet of paper. Individual feathers were spread apart and lice were removed with a camel's hair brush and forceps. All specimens from a single skin were placed in a vial of 70% alcohol, with the host catalogue number. The paper was shaken to remove any lice that might possibly be clinging to it.

The adults were later cleaned and cleared in potassium hydroxide, washed in distilled water, dehydrated by successive strengths of alcohol (30%, 70%, and 100%), placed in xylene, and mounted on slides in Canada balsam. A record of the species of Mallophaga present on each bird was kept, with the numbers of males, females, and immatures noted. These basic data were utilized in a study of the relation between the number of birds infested with Mallophaga and the number of louse species present, and will appear in Part II of this work (Ward, 1957).

[1]Part I of a dissertation, with slight revisions, presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy at the Department of Zoology of the University of Chicago, 1955. Accepted for publication Oct. 8, 1956.

The host nomenclature used here is that of Hellmayr and Conover (1942), brought up to date by the revisions of Conover (1949, 1950a, 1950b) and Wetmore and Phelps (1951).

ACKNOWLEDGMENTS

I am deeply indebted to Professor Alfred E. Emerson of the University of Chicago for his helpful guidance. Mr. Rupert L. Wenzel and Mr. Henry S. Dybas of the Chicago Natural History Museum have given me much valuable advice and use of the facilities of the Division of Insects. Without the use of the collections of the Division of Birds of the above institution, this study would not have been possible. Much valuable advice has been received from Mr. Emmet R. Blake, Curator of the Division of Birds. I wish to express my appreciation for the loan of certain Mallophaga to Miss Theresa Clay, British Museum (Natural History), and Dr. M. A. Carriker, Jr., Popayan, Colombia.

Portions of this work were done while the author was the recipient of a fellowship in Zoology during 1953–55 from the Chicago Natural History Museum and the Department of Zoology of the University of Chicago.

CLASSIFICATION OF TINAMOU HOSTS

The Tinamiformes are an order of terrestrial birds of partridge-like form endemic to the Neotropical region between northern Tamaulipas, Mexico, and Patagonia. Romer (1945) considers the tinamous to be a comparatively ancient relic form of an early tertiary group of weak flying birds with a primitive palate, complete wings and a keeled sternum. Only one extinct genus is recorded. *Tinamisornis* is known from two species from the Monte Hermoso deposits of the Middle Pliocene of Patagonia. An extinct species, *Nothura paludosa* Mercerat, has been described from the Pampean bed of Argentina from the Pleistocene. Extant species of other genera appear from Pleistocene deposits at Luján, Argentina and in cave deposits in Minas Gerais, Brazil (Lambrecht, 1933).

In a study of the structure of the feathers of birds, Chandler (1916) considers the tinamous as an offshoot of the Galliformes. Glenny (1946), reporting on the arterial systems of four genera, believes that the tinamous are more closely related to the Galliformes than to any other groups and that this is not due to convergence. McDowell (1948), in a study of the palate of birds, concludes that the paleognathous palate is an undefinable adaptive feature and not primitive. Wetmore (1951) and Mayr and Amadon (1951) accept McDowell's interpretation of the palate and discard the Paleognathae in their classification of the birds. Mayr and Amadon agree with McDowell that the tinamous and rheas are closely related but doubt that they should be placed in a single order. They believe it highly unlikely that the Galliformes are related to the Tinamiformes. The current opinion of McDowell (unpublished, *fide* Mayr and Amadon, 1951) is that several or all of the Anhimidae, Cracidae and Tinamidae are representatives of some ancient American radiation.

Von Boettischer (1934) discusses the relationships of the extant genera and bases his classification upon color pattern, characters of the bill, nostrils, tarsi, toes, tail, and ecological distribution. He separates the family into three subfamilies as follows:

(1) Subfamily Tinaminae: *Crypturellus*, *Tinamus*, and *Nothocercus*.
(2) Subfamily Rhynchotinae: *Rhynchotus*, *Nothura*, *Nothoprocta*, and *Taoniscus*.
(3) Subfamily Eudromiinae: *Tinamotis* and *Eudromia*.

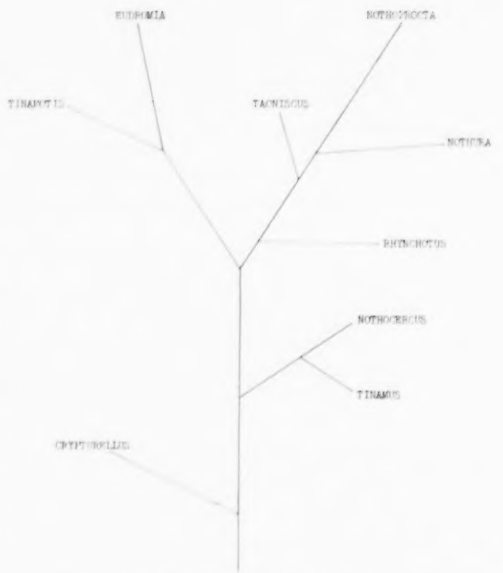


FIGURE 1. Dendrogram of the Tinamidae.

Figure 1 represents a dendrogram of the family Tinamidae as depicted by von Boettischer (1934).

In a review of the Brazilian tinamous, Miranda-Ribeiro (1938) divides them into two subfamilies, the Tinaminae being equivalent to the grouping by von Boettischer and the Nothurinae equivalent to his Rhynchotinae and Eudromiinae. *Crypturellus* is split into three genera, *Orthocrypturellus*, *Crypturornis* and *Crypturellus*. The balance of the genera remain the same.

Todd (1942) gives Miranda-Ribeiro's three groups of *Crypturellus* subgeneric status. Hellmayr and Conover (1942) follow von Boettischer's classification with no mention of suborders and consider *Orthocrypturellus* and *Crypturornis* as synonyms of *Crypturellus*.

The genera *Crypturellus* and *Tinamus* are found in lowland rain forests and low mountains of tropical Central and South America. *Nothocercus* occurs in the subtropical forests and temperate zones of the higher mountains between Costa Rica, Venezuela and southern Peru. The remaining genera are inhabitants of the grasslands in southern South America with certain members of *Rhynchotus*, *Nothura*, *Nothoprocta* and *Tinamotis* attaining the high altitudes of the Andes. On the basis of the biome distribution, the forest-dwellers, *Crypturellus*, *Tinamus*, and *Nothocercus*, would be expected to be more primitive than the genera of the grasslands.

Recent estimates as to the number of species in the family are as follows:

No. of Species	Authority and Date
51	Peters, 1931
73	Miranda-Ribeiro, 1938.
45	Hellmayr and Conover, 1942; Conover, 1949, 1950a and 1950b.
33	Mayr and Amadon, 1951.

This dissimilarity is largely one of differences in assigning the borderline cases to the status of species or subspecies. This may often be attributed to various interpretations of the species definition by different workers in different periods of time.

GENERIC CLASSIFICATION AND HOST DISTRIBUTION OF MALLOPHAGA

The Mallophaga of the Tinamiformes belong to three main groups. The first of these, the Menoponidae, contains two genera found on these birds. *Menacanthus* is a genus of wide host range, found on both tinamous and a wide variety of passerine, piciform and galliform hosts. *Microctenia* is restricted to the tinamous. The second family, the Philopteridae (*sensu* Hopkins and Clay, 1952), contains the greatest number of genera of Mallophaga. Three of these genera, *Pseudolipeurus*, *Pseudophilopterus* and *Tinamotaecola*, are restricted to this host group. The third section constitutes the majority of the tinamou lice. It is restricted to this order except for two species on the Cariamidae (Order Gruiformes). This group of 15 genera (24 as defined by Carriker, 1944, and 18 by Hopkins and Clay, 1952) has been assigned to the Heptapsogastridae.

Carriker (1936) established the Heptapsogastridae on the basis of the unique seven-segmented abdomen and the presence of spiracles on the first visible abdominal segment. The structure of the thorax was also considered to be distinctive, with conditions of complete separation to fusion of the meso- and metathorax.

Due to the almost impossible task of dividing the Ischnoceran Mallophaga into families, it is hard to judge the validity of the Heptapsogastridae. It seems to be a natural group allied to the *Goniodes-Goniocotes* complex of the Galliformes, but it does not deserve separate family rank. I think it is preferable to include the "Heptapsogastridae" as a part of the Philopteridae. Theresa Clay (*in litt.*) is in agreement with me on this point.

The prothorax of the Ischnocera is free from the remaining thoracic segments. The meso- and metathorax are fused dorsally to form a rigid pterothorax which is usually entirely free of the first visible abdominal segment. Indirect evidence (Wilson, 1936) points to the fusion of the true first and second abdominal segments in late embryological development. Therefore the first visible abdominal segment is actually the true second segment. Spiracles occur on the true third to eighth segments. There is a fusion between the apparent eighth and ninth segments which has been observed in *Cuclotogaster heterographus* (Nitzsch) during the third instar (Wilson, 1936). The final result is as follows:

Apparent segment	*True segment*
1	I and II
2 to 7	III to VIII
8	IX and X
9	XI

For the balance of this paper, the true abdominal segments will be designated by Roman numerals.

The classification of Carriker is founded on a misinterpretation of the thorax and abdomen. He interpreted the pterothorax as composed of two separated to completely fused segments and he considered the first spiracle-bearing abdominal segment as a fusion of the first and second segments. Von Kéler (1938) presented a true interpretation of these relationships but it appears to have been overlooked by Carriker in his later papers.

The chaetotaxy of the Ischnoceran pterothorax is so constant that it provides adequate evidence for the delimitation of this structure. In many examined genera there is always a fine ventro-lateral hair arising from a pit in the integument (Clay, 1940). There is also a shorter spine anterior or posterior to the above hair. Several long setae are on the dorso-lateral and posterior margins.

Post-spiracular setae are generally associated with the abdominal spiracles. A post-spiracular sensillus is in contact with the alveolus of each of these setae on segments III to V (Clay, 1954). This sensillus may occur on segment II where spiracles are absent. The true position of a segment may be ascertained by these landmarks.

These structures were studied in all available "heptapsogastrine" species. A pterothorax is present in every species examined and no evidence was found of a partial fusion of the meso- and metathorax. In all of the genera except three the pterothorax shows more or less fusion with the second abdominal segment. Segment II may remain fairly large in proportion to the

other segments or it may be reduced so that it lies embedded in segment III. Spiracles are always lacking on segment II as in other avian Ischnocera but are present on segments III to VIII. A post-spiracular sensillus is usually present and visible on segment II. This segment may be free from III or partially fused with it on the posterior edge of the tergite.

These thoracic features are among the most conservative characters of this group of Mallophaga and a generic classification can be made with these criteria.

I. Abdominal segment II little changed in size when compared with segment III; pterothorax partially joined to segment II medially; segment II free from III.
   Rhopaloceras Taschenberg. (Figure 2).
II. Abdominal segment II considerably reduced in size when compared with III.
   A. Pterothorax free from segment II.
      Kelloggia Carriker. (Figure 3).
      Strongylocotes Taschenberg. (Figure 4).
      Ornicholax Carriker. (Figure 5).
   B. Pterothorax partially united with abdominal segment II; lateral edges of pterothorax and segment II form a sinuous line.
      1. Second abdominal segment separate from the third.
         Lamprocorpus Carriker. (Figure 6).
         Heptapsogaster Carriker. (Figures 7–11).
         Petenosoma Ewing. (Figure 12).
         Trichodopeostus Carriker. (Figure 13).
         Megaginus Carriker. (Figure 14).
         Discocorpus Carriker. (Figure 15).
      2. Posterior margin of tergum II joined to anterior margin of tergum III medially.
         Megapeostus Carriker. (Figure 16).
         Pterocotes Ewing. (Figure 17).
         Physconella Paine. (Figure 18).
   C. Pterothorax completely fused with tergite II; lateral edges of pterothorax and abdominal segment II form a straight line.
      1. Second abdominal segment separate from the third.
         Cuclotocephalus Carriker. (Figure 19).
      2. Posterior margin of tergite II joined to segment III.
         Nothocotus Carriker. (Figure 20).

Other structures, especially of the head and abdomen, are useful in segregating these genera but give little or no indication of relationship in a phylogenetic sequence. For instance, *Rhopaloceras* is the only known Mallophagan genus with ctenidia on the paratergites yet this feature alone does not help to classify it. Similarly, only *Pectenosoma* possesses rows of raised papillae on the dorsal surface of the integument of the thorax and various abdominal segments.

Changes made in the recognition of genera other than those mentioned by Hopkins and Clay (1952) are as follows:

(1) *Kelloggia* Carriker = *Kelloggia* Carriker + *Austrokelloggia* Carriker. These have been segregated on the absence of coni and the division of abdominal tergite II into two lobes in *Kelloggia* and the presence of coni and undivided second tergite in *Austrokelloggia*. The presence or lack of coni has been shown by Clay (1946) to be a very variable feature—"although of prime importance in the separation of species, [they] are not necessarily of generic importance." Some species of *Kelloggia* from *Tinamus* show very reduced membranous clavi. The condition of the second abdominal tergite is intermediate in the species parasitizing *Nothocercus*. Two lobes are discernible but are connected by a membranous, less sclerotized area. For these reasons it seems best to consider *Austrokelloggia* Carriker, 1936, a synonym of *Kelloggia* Carriker, 1903. At most *Austrokelloggia* might deserve subgeneric status.

(2) *Megapeostus* Carriker = *Megapeostus* Carriker + *Heterogoniodes* Carriker. Carriker has separated *Megapeostus* from *Heterogoniodes* mainly on the basis of the male genitalia and the structure of the marginal carina. He characterizes the former genus with asymmetrical male genitalia and internal projections of the marginal carina. The latter genus has symmetrical male genitalia and lacks the numerous internal projections of the marginal carina. *Heptapsogaster soui* Carriker and *Heptapsogaster petersi* Carriker are actually members of *Megapeostus*. They have marginal carinae similar to those of *Heterogoniodes*

EXPLANATION OF FIGURES

Dorsal aspect of the pterothorax and abdominal segments II and III. Chaetotaxy is only indicated on the right side.

FIG. 2. *Rhopaloceras brevitemporalis* Carriker, ♂, ex *Crypturellus obsoletus punensis*.

FIG. 3. *Kelloggia latithorax* Carriker, ♀, ex *Tinamus major peruvianus*.

FIG. 4. *Strongylocotes interruptus* Carriker, ♀, ex *Crypturellus noctivagus garleppi*.

FIG. 5. *Ornicholax olfersi* Guimarães, ♂, ex *Tinamus major latifrons*.

FIG. 6. *Lamprocorpus hirsutus* Carriker, ♂, ex *Nothoprocta o. ornata*.

FIG. 7. *Heptapsogaster grandis* (Carriker), ♀, ex *Tinamus major peruvianus*.

FIG. 8. *H. temporalis* Carriker, ♀, ex *Crypturellus undulatus adspersus*.

FIG. 9. *H. rotundatus* (Rudow), ♂, ex *Rhynchotus rufescens rufescens*.

FIG. 10. *H. testudo* Clay, ♀, ex *Nothoprocta p. perdicaria*.

FIG. 11. *Heptapsogaster* sp., ♀, ex *Eudromia elegans albida*.

FIG. 12. *Petenosoma yapurae* Carriker, ♀, ex *Crypturellus undulatus yapura*.

FIG. 13. *Trichodopeostus aculeatus* (Piaget), ♀, ex *Nothocercus j. julius*.

FIG. 14. *Megaginus emarginatus* Carriker, ♂, ex *Crypturellus obsoletus punensis*.

FIG. 15. *Discocorpus mexicanus* Carriker, ♀, ex *Crypturellus cinnamomeus soconuscensis*.

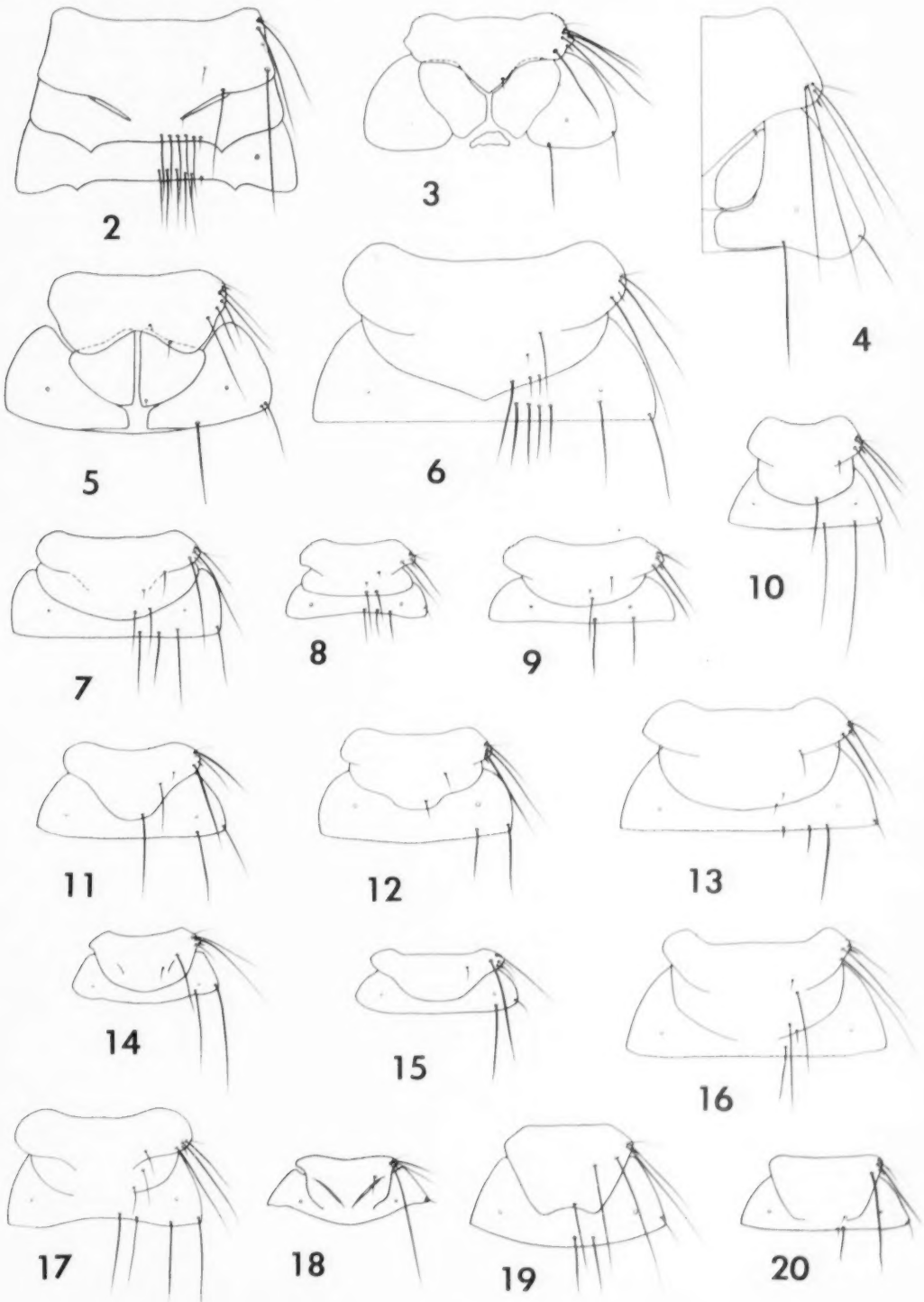
FIG. 16. *Megapeostus clypeiceps* (Giebel), ♂, ex *Crypturellus cinereus*.

FIG. 17. *Pterocotes aberrans* (Carriker), ♂, ex *Tinamus major robustus*.

FIG. 18. *Physconella* sp., ♀, ex *Crypturellus strigulosus*.

FIG. 19. *Cuclotocephalus extraneus* Carriker, ♀, ex *Nothoprocta c. curvirostris*.

FIG. 20. *Nothocotus genitalis* Carriker, ♀, ex *Nothocercus j. julius*.


2
3
4
5
6
10
7
8
9
11
12
13
14
15
16
17
18
19
20

and male genitalia that only exhibit a slight degree of asymmetry. All the species now included in *Megapeostus* may be characterized by the unique structure of the ventral carina. Apparently only in this genus is it interrupted medially with a flattened spatulate tip extending ventromedially on each side. This modification may increase the efficiency of the pulvinus in feeding. *Megapeostus* Carriker, 1936 has page priority over *Heterogoniodes* Carriker, 1936.

(3) *Pterocotes* Ewing = *Pterocotes* Ewing + *Heptapsus* Carriker. *Heptapsus* was separated from *Pterocotes* on the basis of a lessened degree of the extraordinary sexual dimorphism of the head and antennae exhibited by the males of *Pterocotes*. The females are indistinguishable except for slight genitalic differences. The presence of abdominal "scent glands" and the unusual ability of the abdominal segments partly to telescope within one another in both groups serves to unite these into a single genus *Pterocotes* Ewing, 1929, described prior to *Heptapsus* Carriker, 1936.

Table I shows the distribution of Mallophaga genera on the Tinamiformes. The correspondence between the two groups is clearly evident. Of the 17 genera which occur on the Tinaminae, 14 or 82% are indigenous to this group. In contrast, two of five or 40% and one of three or 33% are restricted to the Rhynchotinae and Eudromiinae, respectively. If the criterion of endemicity is used to indicate primitiveness, then the Tinaminae are a more primitive subfamily. This subfamily also harbors the four most primitive "heptapsogastrine" genera in terms of thoracic structure. Although most of the tinamou genera can be immediately identified once a list of the Mallophaga genera parasitizing them is made, the Mallophaga genera serve best to distinguish host categories of greater than generic rank. This is especially true in respect to the major groups designated by von Boettischer.

DISTRIBUTION OF MALLOPHAGA SPECIES GROUPS ON TINAMOU GENERA

In studying the distribution of species groups of Mallophaga genera which occur on more than a single host genus, definite degrees of relationship may be demonstrated between the tinamou genera.

The species groups of *Rhopaloceras* found on *Crypturellus*, *Tinamus* and *Nothocercus* may each be distinguished by details of the male genitalia

TABLE I

DISTRIBUTION OF MALLOPHAGA GENERA ON THE TINAMIFORMES

MALLOPHAGA GENERA	HOST GENERA								
	Tinaminae			Rhynchotinae				Eudrominae	
	Tinamus	*Crypturellus*	*Nothocercus*	*Rhynchotus*	*Nothoprocta*	*Nothura*	*Taoniscus*	*Eudromia*	*Tinamotis*
Rhopaloceras	X	X	X						
Kelloggia	X	X	X						
Strongylocotes	X	X	X	X		x			
Ornicholax	X								
Lamprocorpus					X				
Heptapsogaster	X	X	X	X	X	X	X	X	X
Pectenosoma		X							
Trichodopeostus			X						
Megapeostus	x	X							
Pterocotes	X	x	X						
Physconella		X	X						
Megaginus		X							
Discocorpus		X							
Cuclotocephalus					X				
Nothocotus			X						
Pseudolipeurus	X	X	X						
Pseudophilopterus	y	y							
Tinamotaecola								X	X
Microctenia	y	y							
Menacanthus	y	y		X	y	y		y	

X—Present on all species of a host genus except for *Cuclotocephalus*, *Lamprocorpus*, *Megaginus* and *Discocorpus* which are restricted to certain species groups.

x—Present on one or two species of a host genus.

y—Present on members of a genus but exact distribution not fully known.

and the internal sclerotized bands of the female genitalia. The female genitalia of the species from *Crypturellus* and *Nothocercus* are more similar than those from *Tinamus*.

Kelloggia was formerly separated into three distinct genera, each on a different host genus. The species groups on *Nothocercus* and *Crypturellus*, previously the genera *Austrokelloggia* and *Hypocrypturellus* respectively, both have conspicuous coni. These are extremely reduced in the species on *Tinamus*. The pterothorax and abdominal segment II are more similar in the species of *Kelloggia* on *Nothocercus* and *Crypturellus*.

The extreme degree of sexual dimorphism exhibited by the males of the genus *Pterocotes* from *Tinamus* was previously noted. A single species is known from *Crypturellus*. *P. cylindratus* (Clay), closely allied to the species groups on *Nothocercus*, is known from *Crypturellus n. noctivagus* and *C. n. zabele*.

Megapeostus, known from all species of *Crypturellus*, is found on a few subspecies of *Tinamus major* in South America. It is undoubtedly a derivative of one of the *Crypturellus* inhabiting species.

Heptapsogaster contains more species than any other tinamou inhabiting genus. It is the only one presently known to parasitize all the host genera of the order. Three closely related groups, *temporalis*, *mandibularis* and *tuxtlae*, are found on *Crypturellus*. *H. minuta*, *parvula* and *grandis* occur on *Tinamus*. They apparently are derived from the same stock as those on *Crypturellus* but are not related to them. Only a single group occurs on *Nothocercus*. This one is closely related to *H. temporalis*. On the remaining tinamous, *Heptapsogaster* has speciated to fill a variety of niches occupied by members of other genera on the Tinaminae. Distinct groups such as *H. tesselata* on *Nothoprocta*, *H. rotundata* on *Rhynchotus*, and *H. dilatata* on *Nothura* show clear affinities to the general "heptapsogastrine" stock. They are all presumed to be inhabitants of the back niche. The *minor* group contains species with an elongated abdomen and narrower heads. It is the only group of *Heptapsogaster* with a body form approximating that of the wing niche dwellers. Representatives occur on *Taoniscus*, *Nothura* and *Nothoprocta*. The single species on *Taoniscus* shows greater divergence than those on the other two host genera. The remaining species on the Rhychotinae and Eudromiinae appear to form a natural group which has speciated to occupy two niches on most of the host genera. *Rhynchotus* and *Nothoprocta* both contain species living on the head and back, *Nothura* and *Eudromia* both have only head-dwelling species, and *Tinamotis* has apparently just the back-dwelling form. The head niche species on *Nothoprocta cinerascens* shows such a degree of sexual dimorphism in the male that Carriker placed it in a separate genus *Heteropeostus*.

On the basis of the male genitalia, closer affinities are exhibited between the species of *Pseudolipeurus* on *Crypturellus* and *Nothocercus* than between those on *Crypturellus* and *Tinamus*. *Pseudophilopterus* is recorded from so few species that it is not currently known whether its species on *Crypturellus* and *Tinamus* form two distinct groups.

Tinamotaecola has speciated on *Eudromia* and *Tinamotis*, but unlike *Pseudolipeurus*, has no distinct groups inhabiting each host genus.

Menacanthus is of sporadic occurrence and cannot be divided into species groups. The species of *Microctenia* from *Tinamus* have a pair of tergocentral setae on either side of the midline while those on *Crypturellus* have three tergocentrals in the same position.

From this brief review of the distribution of the major species groups of Mallophaga, it is seen that they are far more useful than the genera proper in an analysis of the generic relations of the hosts. The overall picture is one of a close conformity to the arrangement by von Boettischer. Only a single change in his dendrogram seems necessary. Most of the species groups on the Tinaminae demonstrate clearer affinities between *Crypturellus* and *Nothocercus* than between *Tinamus* and *Nothocercus* as depicted by von Boettischer. It would be desirable to place *Nothocercus* on the same branch as *Crypturellus*.

DISTRIBUTION OF MALLOPHAGA SPECIES ON TINAMOU SPECIES

Genus **Tinamus**

The described species of *Rhopaloceras* fall into two main groups. The first, typified by *R. oniscus* (Nitzsch), was described from *T. solitarius*. A second closely related species, *R. carrikeri* Eichler, was named for the description of *R. oniscus* by Carriker from *T. tao septentrionalis*. Series of available specimens are too small to distinguish the species on *tao* and *solitarius*. In no event, can they be mistaken for the much smaller species on *T. major*. Carriker has described *R. genitalis* and *R. simplex* from this group, but the material is inadequate for separation. No members of this genus have been found on *T. osgoodi* and a single female has been found on *T. guttatus*. This individual is closer to the species on *T. major* than to that on *T. tao*.

Two main groups of *Kelloggia* occur on *Tinamus*. Carriker placed the first of these, with extreme sexual dimorphism, in a separate genus, *Heptagoniodes*. A pair of closely related species, *K. agonus* (Nitzsch) and *K. dimorphus* (Carriker), which may be separated only by differences in the proportions of the male genitalia, exist on *T. tao tao* and *T. tao weddelli*. *K. clayi* (Guimarães

and Lane) from *T. solitarius* and *K. mirabilis* (Carriker) on *T. tao septentrionalis* may be readily distinguished from each other and from *K. agonus* and *K. dimorphus* by striking differences in their male genitalia. A species found on *T. tao kleei* is known only from females, so its exact position remains in doubt.

The remaining species of *Tinamus* are parasitized by members of the second group which are not sexually dimorphic. Five species can be distinguished on the basis of male genitalia and slight differences in the measurements of various structures. *T. major* is parasitized by three species. *K. mexicanus* Carriker is on *T. m. percautus* and *T. m. robustus*. *K. brevipes* Carriker, originally described from *T. m. castaneiceps* in Costa Rica, is now known from *T. m. zuliensis*, *m. olivascens*, *m. ruficeps*, *m. serratus* and Brazilian specimens of *m. peruvianus*. The third species, *K. latithorax* Carriker, whose type host was *T. m. peruvianus*, has subsequently been found on *m. tuscipennis*, Panama specimens of *m. castaneiceps*, *m. saturatus*, *m. latifrons*, *m. major* and Bolivian and Peruvian *m. peruvianus*. *K. ruficeps* Carriker from *T. m. ruficeps* and *K. serrati* Guimarães from *T. m. olivascens* appear to be identical with *K. brevipes*. Likewise, *K. chocoensis* Carriker from *T. m. latifrons* and *K. taoi* from *t. tao* (host probably erroneous) are synonyms of *K. latithorax*. Two new species occur on *T. guttatus* and *T. osgoodi*.

The closely related species of *Strongylocotes* are mainly distinguished by size and proportions. Contrary to the situation in most of the genera found on *Tinamus*, it cannot be stated that certain host species are related on the basis of parasite distribution. *S. wernecki* Guimarães and Lane, restricted to *T. solitarius*, is the largest species in this group. *S. taoi* Carriker, *S. weddelli* Carriker and *S. carrikeri* Guimarães have been described from *T. tao septentrionalis*, *t. weddelli* and *t. tao* respectively, but do not seem distinct and probably are synonyms of *S. taoi* Carriker. Several names (*S. cordiceps*, *ruficeps*, *angulocapitis*, and *boliviensis*) have been proposed by Carriker for the species occurring on *T. major*. Due to the limited material available, there seems little reason for this excessive splitting. *T. o. osgoodi* and *o. hershkovitzi* have a species which is very closely allied or identical with the one on the *T. major* group. The undescribed species on *T. guttatus* is considerably smaller than other species on *Tinamus*.

Ornicholax was divided into three main groups by Guimarães (1948). With the study of further material, his categories seem justified. *O. alienus* (Giebel) is found on *T. solitarius*. The populations on *T. tao tao* and *T. tao septentrionalis* have each been treated as separate species or subspecies, *O. taoi* Carriker and *O. carrikeri* Guimarães, respectively. There seem to be no significant differences between any of the populations found on all the subspecies of *T. tao*. *O. alienus* is possibly identical with *O. taoi*; if this is the case, *O. alienus* has priority. The second group contains three to four species typified by *O. robustus* Carriker which was originally described from *T. m. castaneiceps*. Additional records show this species to occur on possibly all subspecies of *T. major* except *T. m. major*, *peruvianus*, and *serratus*. *O. mexicanus* Carriker, 1944, was described from *T. m. percautus*, but is not distinct from *O. robustus* Carriker, 1903. No males have been observed from *T. m. peruvianus*, the type host of *O. boliviensis* Carriker, so its validity cannot be ascertained. Specimens from *T. m. serratus* may be members of the species. Two new species occur on *T. guttatus* and *T. o. osgoodi*. On the basis of male genitalia and general proportions, the species on *o. osgoodi* and *o. hershkovitzi* show closer affinities to *O. robustus* than the species on *T. guttatus*. *O. olfersi* Guimarães differs considerably from the balance of the species in the male genitalia and shape of the head. Originally described from *T. m. major*, it is now known from *T. m. olivascens*, *m. serratus* and *m. latifrons*. One Colombian individual of *T. m. latifrons* harbored both this species and *O. robustus*. *O. olfersi* is apparently restricted to the South American subspecies of *T. major*.

Heptapsogaster grandis (Carriker) was orginally described from *T. major peruvianus*, with further records from *m. saturatus*, *m. olivascens*, *m. serratus*, *m. ruficeps*, and *m. major*. Guimarães and Lane (1937) described *H. oliverioi* from *T. solitarius*, but Guimarães (1942a) later considered it a synonym of *H. grandis* (Carriker, 1936) The few specimens available from *T. tao tao*, *t. weddelli* and *T. solitarius* indicate these two species are validly separated by size differences. Two new species on *T. osgoodi* and *T. guttatus* differ from the former by the relative proportions of the two pairs of "scent glands." A second group consists of *H. minuta* (Carriker) and related species. It was first reported from *T. major castaneiceps*. Subsequently, Carriker (1944) considered the population from *T. m. percautus* to be distinct. Additional material from six other subspecies of *T. major* and two subspecies of *T. osgoodi* have been examined. There is no need to split the species. Guimarães (1942a) described *H. keleri* from *T. tao tao*. *H. parvula* (Carriker) constitutes the last species group. It is on all of the host species and subspecies except *T. osgoodi* and *T. guttatus* and cannot be subdivided.

Two species of *Megapeostus* are known from *Tinamus*. *M. alterus* Clay, described from *T. major latifrons*, was on a specimen of *T. m. olivascens*. Its closest relative may be a species on *Crypturellus obsoletus griseiventris*. *M. ruficipitis* Clay is only known from the male holotype from a Peruvian skin of *T. major ruficeps*. It may be a straggler such as *M. parvigenitalis* which occurs on *Crypturellus noctivagus garleppi*.

Pterocotes is represented by three species. *P. taoi* Carriker, whose type host was *T. tao kleei*, is of general occurrence on *T. tao* and its subspecies. A second species, *P. solitarius* Guimarães and Lane, is restricted to *T. solitarius*. *P. aberrans* (Carriker) is present on all subspecies of *T. major*. In 1944, Carriker described *P. colombianus* and *P. mexicanus* from *T. m. serratus* and *T. m. percautus*. The study of series from most of the subspecies of *T. major* shows that *P. colombianus* and *P. mexicanus* are synonymous with *P. aberrans*. The abdominal chaetotaxy and male genitalia of *P. taoi* and *P. solitarius* show closer relationships to each other than either one with *P. aberrans*. This genus has not been reported from *T. osgoodi* or *T. guttatus*.

Pseudolipeurus exhibits a pattern of host distribution similar to that of other genera. *P. taoi* Carriker and *P. peruvianus* Carriker have been described from different host subspecies of *T. tao*. A single male from *T. tao kleei* has been observed so the validity of both species cannot be determined. Material from *T. solitarius* has been identified as *P. taoi* by Guimarães (1942c) and von Kéler (1939a). The shape and size of mesosomal elements of the male genitalia enable two species to be distinguished from the remaining ones inhabiting *Tinamus*. *P. tinami* (Carriker), originally described from *T. major castaneiceps*, is also present on *m. robustus*, *m. fuscipennis*, *m. saturatus*, *m. latifrons* and *o. osgoodi*. Carriker described *P. ruficeps* from *T. m. zuliensis* in 1944 and *P. saturatus* from *T. m. saturatus* in 1953. These cannot be distinguished from *P. tinami*. *P. serratae* Carriker, described from *T. major peruvianus*, is the second species inhabiting the *major* complex. The illustration by Guimarães (1942c) of the male genitalia of a species of *Pseudolipeurus* from *T. m. major* adds an additional host record to this species.

Pseudophilopterus tinami Carriker is only known from its original description from *T. major zuliensis*.

Four species of *Microctenia* are known from *Tinamus*, namely *M. tibialis* Kéler from *T. solitarius*, *M. major* Carriker from *T. m. major*, *M. guimaraesi* Carriker from *T. m. peruvianus*, and *M. heterocephalus* Guimarães from *T. guttatus*. Only the last named species has been studied.

Two species of *Menacanthus* have been described from this host genus, *M. brachygaster* (Giebel) and *M. latacephalus* Carriker from *T. tao* (ssp. ?) and *T. major saturatus*. Further evidence is needed to ascertain whether these records are due to contamination or whether these species actually parasitize *Tinamus*.

Genus **Crypturellus**

Rhopaloceras is poorly represented in the collection so little can be added to the classification by Carriker. The main groups can be separated by the male genitalia. *R. rudimentarius* Carriker is known from nine of the 13 subspecies of *C. soui*. A closely related species, *R. undulatus* Carriker, occurs on *C. undulatus*. Two other allied species are also known, *R. brevitemporalis* Carriker on *C. obsoletus punensis*, and *R. pennaticeps* (Paine and Mann) on *C. tataupa* and *C. parvirostris*. *R. almeidai* Guimarães, different from any species in the genus, is found on *C. n. noctivagus*. The final group has a pair of species, *R. spatulata* Carriker and *R. heterogenitalis* Carriker, described from *C. noctivagus idoneus* and *C. b. boucardi*. A pair of males from *C. cinnamomeus goldmani* and *C. noctivagus duidae* belong to one of these two species but cannot be accurately determined until compared with the types. A third male from *C. n. garleppi* appears slightly different and may be a new related species. Females are known from *C. cinereus*, *C. v. variegatus*, *C. strigulosus* and several subspecies of *C. cinnamomeus*, but cannot be determined without associated males.

Carriker (1955b) has proposed the names *R. variegatus* and *R. cinereus* respectively for a single female from *C. variegatus* and three females from *C. cinereus*. Females of many species of *Rhopaloceras* are separated solely by quantitative characters. With such small series as the ones above, and in the absence of associated males, it is unwise to segregate new species merely because they were found on new hosts which theoretically should harbor new species.

The species of the genus *Kelloggia* on *Crypturellus* form an extremely homogeneous group whose members may generally be distinguished only by means of slight size differences and the male genitalia. *C. cinereus* and *C. berlepschi* are parasitized by closely related species, *K. heterurus* (Carriker) and an undescribed one. *K. nigriceps* (Carriker) is distributed on seven subspecies of *C. soui* while *K. inconspicuus* (Carriker) is known from *C. soui inconspicuus*. Males of this latter species have not been studied, but from Carriker's figure it may be related to *K. obsoletus*. Two species with different male genitalia and chaetotaxy are present on *C. obsoletus*. *K. obsoletus* (Carriker), with *C. o. punensis* as its type host, was reported from *C. o. ochraceiventris* and is known from *o. chirimotanus*. *K. ribeiroi* (Guimarães) described from *C. o. obsoletus*, also occurs on *C. o. griseiventris*. It is the only known species with lanceolate setae on the head and body. The two subspecies of *C. variegatus* are parasitized by *K. coniceps* (Taschenberg). A closely related undescribed species, differing chiefly in size, occurs on *C. brevirostris bartletti*. A complex of six species covers almost the entire balance of the genus. *C. undulatus* and its subspecies are parasitized by *K. undulatus* (Carriker). *K. laticeps* (Guimarães) is found on *C. n. noctivagus*. *K. strigulosus* (Guimarães), whose type host is *C. strigulosus*, also occurs on *C. noctivagus garleppi*. *K. idoneus* (Carriker) described from

C. n. idoneus is also found on *C. n. duidae, transfasciatus* and *boucardi costaricensis*. Originally described from *C. b. boucardi, K. boucardi* (Carriker) is found on all nine subspecies of *C. cinnamomeus*. *K. cinnamomea* (Carriker) from *C. cinnamomeus mexicanus* is indistinguishable from *K. boucardi* (Carriker). One of the two closely related species in the final group has an overlapping host distribution. *K. genitalis* (Carriker) is restricted to Brazilian populations of *C. tataupa tataupa*. In contrast, *K. mendax* (Guimarães and Hopkins) occurs on all of *C. parvirostris* (Brazil, Paraguay, and Bolivia), *C. tataupa lepidotus* (northeastern Brazil), *C. t. inops* (northern Peru), *C. t. peruvianus* (central Peru), and *C. t. tataupa* from Bolivia, Paraguay, and Argentina.

The host distribution of the species of *Strongylocotes* parallels that of *Kelloggia*. A pair of related species, *S. berlepschi* Carriker and *S. abdominalis* Carriker, inhabit *C. berlepschi* and *C. cinereus*. *C. soui* is parasitized by *S. subconiceps* Carriker, or a flock of closely allied forms on different host subspecies. Carriker has described three subspecies of *S. subconiceps* (*S. s. caucae* on *C. s. caucae* and *C. s. soui, S. s. felisae* on *C. s. caqueta* and *C. s. harterti*, and *S. s. perijae* on *C. s. mustelinus*), and Guimarães and Lane a single one (*S. s. albigularis* on *C. s. albigularis*). The male specimens observed have been from *C. s. modestus, s. meserythrus, s. nigriceps, s. harterti, and s. inconspicuus*. These all conform to *S. subconiceps*. *C. obsoletus* harbors several closely related species. *S. nirmoides* (Carriker) was described from *C. obsoletus punensis*. A probable synonym of *S. nirmoides* is *S. intermedius* Carriker from *C. o. ochraceiventris;* a single male from *C. o. chirimotanus* fits either of these species descriptions.

The second group consists of *S. complanatus* (Piaget), described from *C. o. obsoletus* and also present on *C. o. griseiventris*. Another major group occurs on *C. variegatus* and *C. brevirostris bartletti*. *S. variegatus* Carriker (described from subspecies *salvini*) is on the former; *S. setifer* Hopkins and *S. caquetae* Carriker (described from the nominate subspecies) are probable synonyms. An undescribed species is on *C. brevirostris bartletti*. The remaining species, except those on *C. tataupa* and *C. parvirostris*, have been considered subspecies of *S. interruptus* by Carriker (1953b). They do form a closely related complex, but the various components deserve specific rank. *S. limai* Guimarães, whose type host was *C. undulatus vermiculatus*, is also found on the other subspecies of *C. undulatus*. *S. noctivagi* Clay seems to be confined to *C. noctivagus noctivagus* and *C. n. zabele*. *S. interruptus* Carriker, described from *C. n. garleppi*, can also contain the population on *C. n. erythropus*. Species from *C. n. idoneus* (*S. idoneus* Carriker) and *C. columbianus* (*S. columbianus* Carriker) have not been observed. The populations on *C. cinnamomeus* and *C. b. boucardi* are identical, and *S. fimbriatus* Clay (1937) from the former host has priority over *S. boucardi* Carriker (1944) from the latter. *S. glabrous* (Carriker) on *C. t. tataupa* and *C. t. peruvianus* and *S. orbicularis* (Carriker) on *C. parvirostris* comprise the final species group.

Each of the three species groups of *Heptapsogaster* will be discussed separately. The *H. temporalis* group may be divided into two sections on the basis of the chaetotaxy of abdominal segment VI in the male. *H. feminina* Carriker from *C. cinereus* has two hairs on this pleurite, while the remaining species have one hair and one spine. *H. boliviensis* Carriker and *H. brasiliensis* Carriker have been described from *C. obsoletus punensis* and *C. o. obsoletus*. Although *H. favus* Carriker from *C. v. variegatus* has not been studied, it appears to be valid. Carriker has described *H. temporalis* from *C. u. undulatus;* it is also present on *C. u. adspersus, u. vermiculatus*, and *u. yapura*. *H. chiñirii* Carriker and *H. sinuensis* Carriker have only been reported from *C. noctivagus garleppi* and *C. columbianus*. *H. boucardi* Carriker was described from *C. b. boucardi* and later was reported from *C. noctivagus idoneus*. The final species, *H. acutiventris* Clay, described from *C. cinnamomeus mexicanus*, differs from the preceding species (except for *H. boucardi*) in terms of the male pleural chaetotaxy. Materials from nine subspecies of *C. cinnamomeus* have been compared with specimens from *C. b. boucardi*. *H. boucardi* is identical with *H. acutiventris* which has priority. Since no individuals of the *H. temporalis* group have been observed from large series of skins of *C. soui, C. tataupa*, and *C. parvirostris*, it is assumed that these Mallophaga species are absent from the aforementioned hosts.

H. tuxtlae and its allies (*H. inexpectata* group of Carriker, 1944) form the second group. *H. benii* Carriker, described from *C. soui inconspicuus*, occurs on at least six other subspecies of *C. soui*. *H. insperata* Hopkins, previously known from its type host, *C. obsoletus obsoletus*, is also present on *C. o. griseiventris*. The similarity of the tergopleural chaetotaxy of the females places the remaining species in a concise section. *H. undulata* Carriker is restricted to the subspecies of *C. undulatus*. *H. magdalenae* Carriker, described from *C. noctivagus idoneus* and subsequently recorded from *C. columbianus*, appears closely related to *H. tuxtlae* Carriker from *C. b. boucardi*. Males from five subspecies of *C. cinnamomeus* and a single one from *C. transfasciatus* do not appear to be separable from *H. tuxtlae*. The recently described *H. potosii* Carriker, 1954, on *C. cinnamomeus mexicanus*, is apparently a synonym of *H. tuxtlae*. An undescribed species with conspicuous differences in the shape of the parameres and mesosomal elements occurs on *C. strigulosus, C. noctivagus*

spencei (Venezuela), and *C. n. erythropus* (British Guiana). The *H. tuxtlae* group is probably absent from *C. cinereus*, *C. berlepschi*, *C. variegatus*, *C. tataupa*, and *C. parvirostris*.

In contrast to other groups whose components may be segregated by abdominal chaetotaxy, members of the *H. mandibularis* group can be separated accurately only by the male genitalia. Carriker has described four subspecies of *H. mandibularis* from *C. soui* (*H. m. tapicollae* from *C. s. meserythrus*, *H. m. nigriceps* from *C. s. nigriceps*, *H. m. albigularis* from *C. s. albigularis* and *H. m. motilonensis* from *C. s. mustelinus*). From the scanty material available, *H. tapicollae* seems a good species containing at a minimum the populations inhabiting *C. s. meserythrus*, and *C. s. modestus*. *H. nigriceps* is likewise a valid species, with additional records from *C. s. inconspicuus*. The recognition of *H. motilonensis* and *H. albigularis* as valid species is questionable. The genitalia of species from *C. obsoletus* are different. *H. crucis* Carriker, from *C. o. punensis*, also occurs on *o. ochraceiventris*. *H. stulta* Clay, a different species, is found on the eastern *C. o. obsoletus*. It was well illustrated by von Kéler (1939a: 240, fig. 13) but was misdetermined as *H. mandibularis*. A single male from *C. o. griseiventris* is close to this species, but may be different. *H. yapurae* Carriker is known from four of the subspecies of *C. undulatus*. *H. idonea* Carriker, *H. garleppi* Carriker, and *H. noctivagi* Clay have been described from *C. n. idoneus*, *n. garleppi*, and *n. noctivagus*. All materials examined from *C. strigulosus*, *noctivagus erythropus*, and *n. spencei* belong to a single species whose genitalia differ from those illustrated for *H. idonea* and *H. garleppi*, but conform perfectly to the figure of *H. stulta* (Clay, 1937: 142, fig. 4b); the figure for the genitalia of *H. noctivagi* had inadvertently been substituted for that of *H. stulta*. It is advisable to refer to the specimens from *C. strigulosus*, *C. n. noctivagus*, *n. erythropus*, and *n. spencei* as *H. noctivagi*. Carriker (1944) described *H. modestae* from *C. b. boucardi*, and later (1954) described *H. cinnamomea* from *C. cinnamomeus mexicanus*. Materials studied from several populations of *C. cinnamomeus* are identical with specimens from *C. b. boucardi*, so *H. cinnamomea* should be considered a synonym of *H. modestae*. The final species group, *H. mandibularis* Carriker, is present on *C. t. tataupa*, and possibly on *C. parvirostris*. Individuals from the latter host are slightly smaller, and may be separable with the study of additional specimens.

Carriker (1944) described two species, *H. costaricensis* from *C. soui modestus* and *H. latacephala* from *C. u. undulatus*, which are supposed to belong to the group of species present on *Tinamus*. Neither of these species has been encountered, and at present these host records should be viewed with suspicion.

In *Pectenosoma* (unlike *Heptapsogaster*) the genitalia are uniform throughout the genus. Species are distinguished by differences in the numbers and rows of thoracic and abdominal papillae and by minor size differences. Carriker (1944) separated materials from *C. soui* into three subspecies, considering the populations from *C. s. inconspicuus*, *C. s. meserythrus*, and *C. s. nigriceps* distinct. Examination of material from his hosts and from six other subspecies of *C. soui* indicates that all of the populations are a single species, *P. inconspicuum* Carriker. *P. punensis* Carriker is known from *C. o. punensis* and *o. ochraceiventris*; a single male from *C. o. obsoletus* is tentatively placed here. The species on *C. variegatus* form another group comprising *P. verrucosum* (Taschenberg) from Brazilian individuals of *C. v variegatus*, and *P. salvini* Guimarães from *C. v. salvini*. Both Guimarães (1950a) and I have found *P. salvini* on specimens of *C. v. variegatus* from British Guiana. *P. parvum* Carriker and *P. subparvum* Guimarães and Hopkins are closely related species present on *C. tataupa* and *C. parvirostris*.

The remaining *Pectenosoma* species are all members of a single group. As in other instances, *C. undulatus* and its subspecies are parasitized by one species, *P. yapurae* Carriker. The complex on *C. noctivagus* is difficult to interpret in this genus. *P. noctivagum* Guimarães, known only from its type host *C. noctivagus noctivagus*, is a distinct species. Carriker has described *P. angustum* from *C. n. garleppi* and *P. boucardi* from *C. b. boucardi*. Specimens examined from these two hosts, with additional series from *C. strigulosus*, *C. noctivagus erythropus*, *n. spencei*, and *n. idoneus*, cannot be clearly divided into species and it may be possible that only a single species is present over this host range. *P. cinnamomeum* Carriker occurs on all the subspecies of *C. cinnamomeus*. One male from *C. transfasciatus* appears to conform to *P. cinnamomeum* rather than to the species on the *C. noctivagus* complex. *P. tinami* Carriker from *Tinamus major percautus* appears to be an instance of contamination from *Crypturellus cinnamomeus sallaei*.

The genus *Megapeostus* can be apportioned into two sections. These have been considered as separate genera, *Megapeostus* and *Heterogoniodes*. An analysis of the characters used to separate them indicates generic separation is not necessary. The *Megapeostus* section contains a range of groups with varying degrees of asymmetry in the male genitalia. The closely related species on *C. soui*, *C. obsoletus*, *C. brevirostris* and *C. tataupa* may be considered as the first main group. *M. soui* and *M. platycephalus* were described by Carriker from *C. soui soui* and *s. inconspicuus*. Examination of over 60 specimens from eight subspecies of *C. soui* indicates that a single species, *M. soui* Carriker, is present on this host. *M. heptarthrogastriformis* Eichler, described from *C. obsoletus punensis* and also

present on *C. o. ochraceiventris* and *o. castaneus*, is closely allied to the above. An undescribed species, with similar parameres but a different head shape, occurs on *C. o. griseiventris*. The species on *C. o. obsoletus* is different from the former, especially in respect to the male genitalia. It appears close to *M. petersi* (Carriker) from *C. t. tataupa* but its true nature will not be known until specimens have been seen from the latter host. A final undescribed species in the group is present on *C. brevirostris bartletti*.

The second group contains a single species, *M. fuscus* Clay, found on *C. v. variegatus* and *v. salvini*. *M. asymmetricus*, *M. parvigenitalis*, and *M. secundus* form a third species group. *M. asymmetricus* Carriker, described from *C. u. undulatus*, is known from all subspecies of *undulatus* except *u. confusus*. A closely related species, *M. parvigenitalis* Carriker, is only known to occur on *C. noctivagus garleppi*. *C. cinnamomeus* and its subspecies are parasitized by a very distinct species, *M. secundus* Clay.

The final group contains two described species, *M. multiplex* Clay from *C. b. boucardi* and *M. idoneus* Carriker from *C. noctivagus idoneus*. Additional material of this group has been seen from *C. strigulosus*, *C. noctivagus erythropus*, *n. spencei*, *n. duidae*, and *C. boucardi costaricensis*. The differences in the male genitalia of *M. multiplex* and *M. idoneus* mentioned by Carriker (1944) do not appear to be constant. There are significant differences in the measurements of females from *C. b. boucardi* and *C. strigulosus*, but insufficient males are available for comparable study. If only a single species can be recognized from this complex, *M. multiplex* Clay has priority. The second section contains three species. *M. clypeiceps* (Giebel) and *M. heterurus* (Carriker) are found on *C. cinereus* and *C. berlepschi*. *M. arcaeceps* (Clay), described from *C. cinnamomeus mexicanus*, is also present on *c. sallaei* and *c. intermedius*.

Pterocotes cylindratus (Clay), the sole species of the genus on *Crypturellus*, occurs on *C. noctivagus noctivagus* and *n. zabele*. Its status has been mentioned previously.

The species of the genus *Physconella* are poorly represented in the material available. *P. cinerea* Carriker, the largest one known from *Crypturellus*, is present on *C. cinereus*. *P. kelloggi* (Paine), on *C. soui*, has striking genitalia. Carriker has described *P. subsimilis* from *C. s. inconspicuus*, but it is indistinguishable from material on seven other subspecies of *soui*. *P. hamata* Carriker has been reported from *C. obsoletus punensis*. Only females of *Physconella* are known from *o. obsoletus* so their relation to *P. hamata* remains unknown. Similarly only females are known from *C. v. variegatus* and *C. brevirostris bartletti*. The balance of the hosts contain species closely allied to *P. genitalis* Carriker from *C. noctivagus garleppi*. *P. emersoni* Carriker, from *C. undulatus adspersus*, is the only other species yet described in this group. It also occurs on *u. undulatus* and *u. yapura*. Males of species related to the above two have been observed from *C. noctivagus atricapillus*, *n. idoneus*, *C. strigulosus*, *C. cinnamomeus vicinor*, *c. praepes*, *C. b. boucardi* and *b. costaricensis*. A maximum of three specimens has been available from each of these hosts so it has been thought unwise to subdivide the group further.

Megaginus has been recently reviewed by Carriker (1955a). He currently recognizes ten forms. Some of his criteria for separation (markings of paratergal plates, minor size, and male genitalia differences) break down when additional material is studied. *M. sordidus* Carriker and *M. felisae* Carriker from *C. berlepschi* and *C. cinereus* are only known from females and have not been observed. However, all Mallophaga from the above hosts are restricted to them, and so these species are retained. Carriker has described *M. latacephalus* from *C. soui meserythrus*, *M. dissimilis* from *C. s. nigriceps*, *M. excavatus* from *C. s. inconspicuus*, and *M. caquetensis* from *C. s. caquetae*. With the study of both sexes from the above subspecies of *soui*, it seems best to consider all these forms as synonyms of *M. emarginatus* Carriker, described from *C. obsoletus punensis*. *M. quadrithorax* Carriker, unencountered since its description from a single male on *Tinamus major fuscipennis*, appears to be a straggler from *C. soui modestus* and is a synonym of *M. emarginatus*. *M. tesselatus* Carriker, from Venezuelian individuals of *C. tataupa*, has not been observed. The tergopleural chaetotaxy of *M. tataupensis* Carriker from *C. t. tataupa* and *t. peruvianus* readily distinguishes it from *M. emarginatus*.

Discocorpus is rather closely related to *Megaginus* in many respects. It mainly occurs on species of *Crypturellus* that *Megaginus* does not parasitize. If intermediate species occurred, it certainly would be combined with *Megaginus*. An undescribed species is present on *C. o. obsoletus*. *D. microgenitalis* Carriker has been described from *C. t. tataupa*. Figures of this species indicate it is closely allied to the previous one. The remainder of the species exhibit close affinities. *D. cephalosus* Carriker from *C. noctivagus garleppi* and an undescribed species on *C. undulatus yapura* and *u. adspersus* compose one group. *D. intermedius* Carriker has been described from *C. noctivagus idoneus*. No material has been observed from this host so specimens from *C. strigulosus* are assigned to this species with reservations. *D. furculus* Carriker has been described from *C. b. boucardi* from Veracruz, Mexico and has also been observed from *b. costaricensis*. *D. mexicanus* Carriker, described from *C. cinnamomeus mexicanus*, has been found on seven additional subspecies of *cinnamomeus* and *C. b. boucardi* from Oaxaca and

Chiapas, Mexico. Single specimens have been encountered on *C. transfasciatus* and *C. columbianus*. The species on *transfasciatus* seems allied to *D. furculus*. The one on *columbianus* appears related to *D. mexicanus*.

The genus *Pseudolipeurus* is divided into a number of distinct groups. The male genitalia show a wider range of divergence than in most Mallophagan genera. *P. macconelli* Clay is on *C. cinereus*. *P. megagenitalis* Carriker from the same host is identical to Clay's species. Two species occur on *C. soui*. *P. subsimilis* Carriker, whose type host is *C. s. inconspicuus*, is also present on *s. nigriceps*. *P. dubius* Guimarães from *C. s. soui* also occurs on *C. s. meserythrus*, *s. harterti*, and *s. albigularis*. *P. soui* Carriker from *C. s. caucae*, *s. mustelinus*, *s. harterti*, and *s. caquetae* is a synonym of *P. dubius*. Three diverse species inhabit *C. obsoletus*. *P. carrikeri* Hopkins is on *C. o. punensis*, *P. conspicuus* Guimarães on *C. o. griseiventris*, and *P. longipes* (Piaget) *on C. o. obsoletus*. The latter species seems related to *P. plumbeus* (Pessôa and Guimarães) found on *C. tataupa* and *C. parvirostris*. A very distinct species, *P. theresae* Guimarães, occurs on *C. v. variegatus*. Two species have been described from *C. undulatus*. *P. genitalis* Carriker (1936) has been described from the nominate subspecies and also occurs on *C. u. yapura* (Guimarães, 1944b). *P. macrogenitalis* (Monteiro de Barros, 1933), described from *C. u. vermiculatus*, differs only in the shape of the apices of the mesosomal apparatus of the male genitalia. At present, it is advisable to consider these as a single species, *P. macrogenitalis*. *C. n. noctivagus* and *n. zabele* harbor a very distinct species, *P. megaceros* Guimarães. The balance of the genus from *Crypturellus* forms a close group. Four species have been described by Carriker, *P. garleppi* from *C. noctivagus garleppi*, *P. sanctaemartae* from *C. n. idoneus* and later from *C. saltuensis* and *C. columbianus* (1953a), *P. similis* from *C. b. boucardi* and *C. cinnamomeus sallaei*, and *P. robustus* on *Tinamus major percautus*. Adequate series of specimens for comparison have been available only from the hosts of *P. garleppi* and *P. similis*. These two species can be distinguished just by means of details of the male genitalia. A single male from *C. n. duidae* seems to be close to *P. garleppi*. Specimens from *C. strigulosus* cannot be separated from the series of *P. similis* encountered on six subspecies of *C. cinnamomeus* and the two subspecies of *C. boucardi*. The measurements for *P. robustus* Carriker fall within the range of *P. similis* and it is undoubtedly a stray from *Crypturellus cinnamomeus sallaei*.

Little can be said concerning the relations of the species of *Pseudophilopterus*, which are extremely rare in collections. Two main groups of species seem to exist, separated by the presence or absence of the postspiracular setae on abdominal tegum III. It appears to be present on species from *C. soui*, *C. obsoletus* and *C. variegatus* and absent on the *C. undulatus*, *C. noctivagus*, and *C. cinnamomeus* group. *P. perijanus* Carriker is only known from its type host, *C. soui mustelinus*. *P. obsoletus* Carriker from *C. obsoletus punensis* has been recorded from Brazilian populations of *o. obsoletus* (von Kéler, 1939a and Guimarães, 1944b). A single female from *C. v. variegatus* is a member of the first group. No material has been observed from *C. undulatus yapura* and *C. saltuensis*, the type host of *P. hirsutus* Carriker and *P. grandior* Carriker. Females have been found on *C. n. noctivagus*, the type host of *P. noctivagus* Guimarães, and *C. strigulosus*. The female from *strigulosus* can be referred to the species group lacking post-spiracular seta III. The final species, *P. similis* Carriker, described from *C. cinnamomeus sallaei*, is also known from *c. mexicanus*.

Two species of *Microctenia* have been described from *Crypturellus*, *M. crucis* Carriker from *C. obsoletus punensis* and *M. soaresi* Guimarães on *C. n. noctivagus*.

A single species of *Menacanthus* is known from *Crypturellus*. *M. coniceps* Carriker has been described from *C. soui caucae*. The presence of this genus on *Crypturellus* requires further verification.

Genus **Nothocercus**

Three species of *Rhopaloceras* have been described from this genus. *R. abbreviatus* Carriker on the two subspecies of *N. nigrocapillus* has close affinities to *R. bonapartei* Carriker described from *N. b. bonapartei*. The third species, *R. laticeps* (Piaget), has been found on *N. j. julius* and *N. j. fuscipennis*.

A single species of *Kelloggia*, *K. intermedia* (Carriker) has been described from this genus. Orginally reported from the two subspecies of *N. nigrocapillus*, Carriker has also collected the species on *N. b. bonapartei*. Additional specimens have been observed from *N. n. nigrocapillus*, *N. bonapartei frantzii*, *N. b. plumbiceps*, and *N. j. julius*. No further division is currently advisable although the small series from *j. julius* provides indications that this population may show significant size differences.

Strongylocotes is present on the species of *Nothocercus*. Two distinct groups apparently exist. The first contains just *S. spinosus* (Piaget) on *N. j. julius*. The second group contains five species described by Carriker. He records *S. subspinosus* from *N. n. nigrocapillus*, *S. peruvianus* from *N. n. cadwaladeri*, *S. bonapartei* from *N. b. bonapartei*, and *S. intercedens* from *N. b. intercedens*. With the examination of additional specimens from *N. b. plumbiceps* and *b. frantzii*, his forms appear indistinguishable and might all be considered under the name of *S. peruvianus*.

A single species group of *Heptapsogaster* occurs on *Nothocercus*. It is most clearly related to *H. femininus* Carriker on *Crypturellus cinereus*, a member of the *H. temporalis* group. Carriker has described *H. nothocercae* from *N. b. bonapartei*, with *N. nigrocapillus cadwaladeri* also listed as harboring the species. Populations on *N. n. nigrocapillus*, *bonapartei plumbiceps*, and *N. b. intercedens* are also referable to this species. An undescribed species with different chaetotaxy is restricted to *N. bonapartei frantzii*. *H. julius* Carriker from *N. j. julius* is also found on *N. j. fuscipennis*. It shows a greater degree of divergence than either of the preceding members of this species group.

Trichodopeostus can be divided into two main groups on the basis of the male genitalia. The first contains a single species, *T. aculeatus* (Piaget) present on *N. j. julius*. Three species are present in the second group. *T. spinosus* Carriker has been described from *N. n. nigrocapillus*, and *T. incertus* Carriker from an immature female on *N. n. cadwaladeri*. This last species is undoubtedly a synonym of *T. spinosus*. *T. praegracilis* Carriker, whose type host is *N. b. bonapartei*, is also found on *b. plumbiceps*. An undescribed species, related to the preceeding, is limited to *N. b. frantzii*.

The species of *Pterocotes* may be separated into two main sections. Each host population possesses members of both groups which often occur on the same individual. Contrary to most instances where two species present on one host differ in many adaptive features as differences in the presence or absense of sexual dimorphism of the antennae, or in the degree of sexual dimorphism (Clay, 1950), these species groups are separated chiefly by size differences. It is possible that the large species inhabits the head niche while the smaller one is restricted to wing and back feather tracts. A single large species, *P. inexpectatus* (Carriker), is assigned to one group. Originally described from *N. b. bonapartei*, it is also found on *N. n. nigrocapillus*, *N. j. julius*, *N. b. intercedens* and *b. frantzii*. Since the genitalia of the specimens appear identical, it does not seem possible to subdivide the group further. The second section with the small species can be segregated into two main groups of closely related species. The first of these, *P. tergalis* (Carriker) was described from *N. n. nigrocapillus*, and is also apparently present on *N. bonapartei intercedens*. A very close undescribed relative of the above differing only in some dimensions of the male genitalia is encountered on *N. j. julius* and *j. fuscipennis*. *P. nothocercae* (Carriker), with rather different genitalia, is found on its type host *N. b. bonapartei* and on *b. plumbiceps*. A close undescribed ally of *P. nothocercae* occurs on *N. b. frantzii*.

Two species of *Physconella*, *P. nothocercae* and *P. julia*, have been described by Carriker from *Nothocercus*. In addition to its type host, *N. n. nigrocapillus*, Carriker (1944) has reported *P. nothocercae* from *N. b. bonapartei*. Additional specimens have been observed from his hosts and from *N. b. plumbiceps*, *b. intercedens*, and *b. frantzii*. The closely related *P. julia* is only known from *N. j. julius*.

Nothocotus contains five species, all described by Carriker. *Nothocotus parvithorax*, *N. centralis*, *N. subsimilis*, and *N. genitalis* all form a closely related group. The first two species were described from *Nothocercus b. bonapartei* in different areas, while the latter two species are known respectively from *Nothocercus nigrocapillus* (both subspecies) and *Nothocercus j. julius*. *Nothocotus distinctus*, with a different head shape in the male and unique genitalia, is restricted to *Nothocercus bonapartei frantzii*.

Pseudolipeurus is poorly known on *Nothocercus*. Carriker has described three species, one from each of the main host groups. *P. grandis* was originally described from a single female on *N. n. nigrocapillus*, and the alleged male described by him (1944) was from *N. b. bonapartei*. This latter identification is an instance of contamination, from (possibly) *Crypturellus noctivagus idoneus* from the same locality. A male has been observed from the type host, and its genitalia are quite distinct. Two other species, *P. verendus* Carriker and *P. bonapartei* Carriker, are recorded from *N. j. julius* and *N. b. bonapartei*.

Genus **Rhynchotus**

Strongylocotes lipogonus (Nitzsch) is found on all the subspecies of this monotypic genus. *S. alticola* Carriker, described from a population of *R. rufescens maculicollis*, is found not valid after study of additional specimens. Females from *R. r. rufescens* from Reyes and Buena Vista, Bolivia, and Vaccaria, Brazil may be distinguished from all other populations by the greater length of the vulval hairs.

The remaining Ischnocera belong to the genus *Heptapsogaster* and are members of three species groups. *H. rotundata* (Rudow) is present on all subspecies. No differences exist between any of the populations studied except in the length of the lateral abdominal seta of tergum VI. There is a noticeable difference in the specimens from *R. r. rufescens* and the other two populations, *r. maculicollis* and *r. pallescens*. This does not seem worthy of taxonomic recognition, especially since the specimens of *R. r. maculicollis* are all from a single locality. The second group consists of three species. *H. latithorax* (Carriker) is sympatric with the other two, *H. crenulata* (Carriker) from *R. r. maculicollis*, *r. pallescens*, and *r. catingae*, and *H. sexpunctata* (Piaget) on *R. r. rufescens*. The latter two are large species, separated by genitalia and proportions from the very much smaller *H. latithorax*. The antennae of *H. latithorax* are filiform while those of *H.*

crenulata and *H. sexpunctata* are dimorphic in the male. This indicates a difference in mating behavior which would tend to isolate the species. The last group consists of a single species, *H. sexsetosa* (Piaget), known from all the subspecies except *R. r. catingae*. Carriker (1944) has described a second species, *H. secunda* from *R. r. maculicollis*. His diagnostic features do not hold true and with the small amount of material available subdivision does not seem necessary.

A single menoponid, *Menacanthus arctifasciatus* (Piaget), described from *R. rufescens* (subspecies ?) is known from all subspecies except *R. r. pallescens*.

Genus **Nothoprocta**

Carriker has described two species of the genus *Lamprocorpus* from this host genus. In both instances there has probably been a misidentification of the hosts. *L. spinosus*, described from *N. pentlandii ambigua*, has not been subsequently encountered on the type host or other subspecies of *pentlandii*. Numerous specimens have been found on *N. curvirostris peruvianus* and *c. curvirostris*. Material subsequently collected by Carriker has been from *c. peruvianus*. It seems that *curvirostris* is the true host of this species. *L. hirsutus* was described from *N. ornata branickii* from Lake Titicaca, Peru. The subspecies of *ornata* present at this locality is *ornata*. Additional specimens of *L. hirsutus* are known from *o. ornata* and *o. rostrata*. A single female has been encountered on a skin of *N. taczanowskii*. This is an undescribed species related to *L. hirsutus*.

Four diverse species groups of *Heptapsogaster* occur on *Nothoprocta*. The first group contains three species which appear to occupy the head niche filled by *Lamprocorpus* on *N. ornata*, *N. curvirostris*, and *N. taczanowskii*. *H. teres* (Clay), whose type host was *Nothura maculosa peruviana* and which was also recorded by her from *Nothoprocta p. perdicaria*, definitely does not occur on *Nothura* It is restricted to *Nothoprocta p. peridicaria* and *p. sanborni*. The remaining species, *H. carrikeri* (Clay) and *H. subteres* (Carriker), are restricted to *N. cinerescens* and *N. pentlandii pentlandii*. The second group consists of a single species, *H. testudo* Clay, described from *Nothura maculosa peruvianus* (1937). In 1944, Carriker described *H. heterura* from *Nothoprocta cinerascens*; it is a synonym of the above species. Materials from the two subspecies of *N. perdicaria* and *N. cinerascens* cannot be distinguished from each other and confrom perfectly to *H. testudo* Clay. Evidently a mislabeling of material has occurred, similar to the case of *H. teres* described in the same paper. The third group contains three species, apparently back inhabitants. *H. chacoensis* (Carriker) has been described from *N. cinerascens* and is limited to that host. Specimens from *N. perdicaria* are very close to *H. chacoensis* but deserve specific rank. An undescribed species on *N. pentlandii pentlandii* and *pentlandii oustaleti* is distinct from the two preceeding ones. The final group contains three to four species. *H. truncata* Carriker was originally recorded from *N. ornata branickii* at Lake Titicaca. As with *Lamprocorpus hirsutus*, the type host is actually *N. o. ornata*. *H. ornata* Carriker, later described from *N. o. ornata*, is a synonym of the above species. *H. tesselata* Carriker, described from *N. curvirostris peruviana*, is also found on *c. curvirostris*. The species of the *H. tesselata* group on *N. taczanowskii* is extremely close to *H. truncata* but it may be separable. *H. pentlandii* Carriker is only known from its description from *N. pentlandii pentlandii*. Judgment on the presence of this species on *pentlandii* should be held in abeyance until further specimens have been encountered.

Carriker has divided the species of *Cuclotocephalus* into two groups, *C. extraneus* and *C. secundus*. He believes that species of both these groups coexist on the same host. This current study does not confirm his contention. Three species of the *C. extraneus* group have been described, *C. extraneus* Carriker from *N. ornata branickii* at Lake Titicaca (=*o. ornata*), *C. ornatus* Carriker from *N. o. ornata* at Callipampa, Bolivia, and *C. similis* Carriker from *N. pentlandii pentlandii*. Specimens have been observed from *N. o. ornata* and *N. c. curvirostris* which fit *C. extraneus* perfectly. *C. ornatus* may be considered identical with *C. extraneus*. The second group contains *C. secundus* Carriker from *N. pentlandii oustaleti* and *pentlandii pentlandii*, and *C. incachacae* Carriker from *N. o. ornata*. Only *C. secundus* has been encountered, both times on the two subspecies of *pentlandii* where Carriker found it. From the evidence available, it seems that *C. extraneus* is restricted to *N. ornata* and *N. curvirostris*, and *C. secundus* occurs on *N. pentlandii*.

A single species of *Menacanthus*, *M. nothoproctae* Carriker, has been described from *N. cinerascens*. Members of this genus have also been observed from *N. perdicaria*, *N. pentlandii pentlandii*, and *N. curvirostris*. *Menacanthus* is probably a normal parasite of *Nothoprocta*.

Genus **Nothura**

A single species of *Strongylocotes* occurs on *Nothura*. *S. tinami* (Rudow) is restricted to *N. boraquira* and is distributed on the Bolivia, Brazil and Paraguay populations of the host.

As in *Nothoprocta*, several distinct groups of *Heptapsogaster* are present on *Nothura*. *H. boultoni* Clay constitutes the first group. It has the same host range and distribution as *Strongylocotes tinami*. The wing niche group includes three species. *H. boraquirae* Clay only occurs on *N. boraquira*. The remaining two species are rather closely related to each other and may be

distinguished only by means of the male genitalia and paratergal chaetotaxy. *H. boliviana* (Carriker), described from *N. maculosa oruro* (=*darwinii agassizii*), is known from *N. darwinii agassizii* and *d. boliviana*. *H. minor* Hopkins, a new name for *H. minuta* (Carriker), was described from an Uruguayan specimen of *N. maculosa maculosa*, erroneously identified as *maculosa nigroguttata* (Carriker, 1936). This species has been encountered on *N. maculosa annectens*, *m. maculosa*, *m. paludivaga*, and *m. major*. Only a few specimens from *N. chacoensis* and *N. minor* were available, and at present they are considered as *H. minor*. The final group has a single described species, *H. dilatata* (Rudow) from *N. boraquira*.

A species of *Menacanthus* has been encountered on *Nothura m. maculosa* (Guimarães, 1947b). As additional material is known from two other subspecies of *maculosa*, it seems that this genus is normally found on *Nothura*.

Genus **Taoniscus**

The single species of *Heptapsogaster* known from this monotypic genus has been previously discussed.

Genus **Eudromia**

An undescribed species of *Heptapsogaster* is found on *Eudromia elegans* and its subspecies (*elegans, intermedia, multiguttata, formosa, devia, albida*, and *patagonica*). Another undescribed *Heptapsogaster* from *E. mira* is significantly smaller and probably represents a second species. Both of these species show affinities with *H. teres* which parasitizes *Nothoprocta*.

Tinamotaecola has at least one undescribed species on *Eudromia*. The material from *E. elegans elegans, e. intermedia, e. formosa*, and *e. albida* belongs to one species. The single known male from *E. mira* is much smaller than any of the preceding individuals and it may be a separate species.

Menacanthus is present on several of the subspecies of *E. elegans*.

Genus **Tinamotis**

Carriker has described a single species of *Heptapsogaster, H. andinae* from *Tinamotis pentlandii*. Specimens indistinguishable from this species have been observed from *T. ingoufii*.

Tinamotaecola andinae Carriker was originally encountered on *T. pentlandii* in Bolivia. Further specimens have been found on skins of this host from Peru and Chile. The few specimens available from *T. ingoufi* are conspicuously smaller in size and may be a separate species.

AVIPARASITOLOGICAL CONCLUSIONS

On the basis of the distribution of Mallophaga species on the genus *Tinamus*, two main groups of the genus may be distinguished. In every Mallophaga genus, it is noted that one group of related species is found on *T. tao* and *T. solitarius* while the other is found on *T. major, T. osgoodi* and *T. guttatus*. Distinct species of *Kelloggia, Strongylocotes* and *Pterocotes*, and possibly of *Ornicholax* are found on *T. tao* and *T. solitarius*. There appears to be a sufficient divergence, using the Mallophaga alone, to consider both these birds as distinct species. In the second group, both *T. osgoodi* and *T. guttatus* contain species which are not shared between themselves or with *T. major*. The species present on *osgoodi* are more closely related to those encountered on *major* than on *guttatus*. There seems to be no evidence that *osgoodi* or *guttatus* should be combined with *major*. The distribution of certain species of *Kelloggia, Ornicholax* and *Pseudolipeurus* provides evidence that there is some geographical differentiation among the subspecies of *T. major*.

The genus *Crypturellus* can be divided into three main sections on the basis of its Mallophaga fauna. The first group consists of *C. cinereus* and *C. berlepschi*. The second contains *C. soui, C. obsoletus, C. brevirostris, C. variegatus, C. tataupa* and *C. parvirostris*. The last section holds the balance of the species—*C. undulatus, noctivagus, strigulosus, transfasciatus, colombianus, boucardi, saltuensis*, and *cinnamomeus*. This pattern of distribution occurs in many genera of Mallophaga. There is no overlap of Mallophaga species on *C. cinereus* and *C. berlepschi*—an indication of their specific status. Although *C. soui* is one of the most widespread of Central and South American birds, ranging from southeastern Mexico to southern Peru and Rio de Janeiro, Brazil, there is little diversity in the Mallophaga fauna found throughout the host range. There are only signs of divergence in the subspecies *inconspicuus* from eastern Bolivia, central and southern Peru, and *nigriceps* from eastern Ecuador and northeastern Peru. A basic dichotomy is exhibited in *C. obsoletus*. One group of Mallophaga species is present on *C. o. punensis, o. ochraceiventris, o. castaneus* and *o. chirimotanus*, all west South American subspecies, while another group is present on the eastern *C. o. obsoletus* and *o. griseiventris*. In the case of *Megapeostus* and *Pseudolipeurus*, there are even different species on *C. o. obsoletus* and *o. griseiventris*. Unfortunately no Mallophaga were found on the single available specimen of *C. o. cerviniventris* from Venezuela. From the evidence of Mallophaga distribution, *C. obsoletus* would be split into two species. The Mallophaga present on *C. tataupa* and *C. parvirostris* are extremely close to each other and usually differ only in quantitative characters. Most of the species appear to be more closely related to those occurring on the *obsoletus punensis, o. ochraceiventis*, etc. section than to any other species of *Crypturellus*. The species on *C. variegatus* are all quite distinct and

no differences exist between the Mallophaga present on its subspecies except for *Pectenosoma*. Two of the three species known from *C. brevirostris bartletti*, from the genera *Kelloggia* and *Strongylocotes*, show very close affinities to *C. variegatus*. The third, a species of *Megapeostus*, resembles the species found on *C. soui*. The third group of *Crypturellus* contains species of birds whose Mallophaga fauna is less diversified than the preceeding groups. These birds may be of more recent origin or the environment of the Mallophaga on these birds may be more uniform than that on the other host species. *C. undulatus* posesses a distinct fauna and the species on its six subspecies give no indication that any further subdivision of the species is necessary. The species found on *C. n. noctivagus* and *n. zabele*, with one exception, are different from those encountered on the remaining forms referred to as *noctivagus*. *C. noctivagus garleppi* has a distinctive group of Mallophaga closely related to the homogeneous group found on *C. n. duidae*, *n. idoneus*, *n. erythropus*, and *C. strigulosus*. These last four forms appear to have close affinities to *C. boucardi*. The Mallophaga on *C. cinnamomeus* are distributed throughout its ten subspecies. No differentiation of any sort has been detected. Certain of the species, *Kelloggia boucardi* (Carriker) and *Discocorpus mexicanus* Carriker, on *C. cinnamomeus* appear to have become established on Mexican populations of *C. b. boucardi* from Chiapas and Oaxaca while Veracruz material of this subspecies and *boucardi costaricensis* from Honduras, Nicaragua and Costa Rica show definite relations to the northern South American group of *C. noctivagus* as *n. idoneus*. The available specimens from *C. transfasciatus* are divided in their relations between *C. cinnamomeus* and *C. boucardi*. Lack of sufficient material from *C. saltuensis* and *C. colombianus* prevents any further statement than that they show relations to the *cinnamomeus-boucardi-noctivagus idoneus* group. On the basis of the evidence from the Mallophaga, it seems that *C. cinnamomeus* is a distinct species. *C. boucardi*, *C. noctivagus idoneus*, *n. duidae*, *n. erythropus* and *C. strigulosus* form a closely related species. *C. noctivagus garleppi* is probably distinct and *n. noctivagus* and *n. zabele* are definitely distinct.

In analyzing the Mallophaga on *Nothocercus*, two main groups of species are apparent. One is found on *N. julius* and the other on *N. bonapartei* and *N. nigrocapillus*. The differences between the Mallophaga found on *N. bonapartei frantzii* and *b. bonapartei* are of the same magnitude as those found between parasites on different species of *Crypturellus*. By the same criteria used previously, these would be considered distinct. In any event, the subspecies *bonapartei* and *plumbiceps* of *bonapartei* are closely allied in contrast to *b. frantzii*, and appear to exhibit closer affinities with *N. n. nigrocapillus* than to *N. bonapartei frantzii*. Unfortunately no skins of *N. b. discrepans* have been available to examine for Mallophaga.

Little differentiation has occurred on the bird populations constituting *Rhynchotus rufescens*. This can be considered as a single species.

Two main groups of *Nothoprocta* are discernible. The presence of *Lamprocorpus* and the *Heptapsogaster tesselata* group readily identify the species group containing *N. ornata*, *tanezanowskii*, and *curvirostris*. The second group of *Nothoprocta*, characterized by Mallophaga of the *Heptapsogaster teres* and *H. chacoensis* groups, consists of *N. perdicaria*, *N. cinerascens*, and *N. pentlandii*. In the first group, the study of material from *N. ornata rostrata* and *o. ornata* shows that no great differences exist between them while rather striking differences exist between *N. ornata* and *N. curvirostris*. These are considered as distinct species. The relations between members of the second group are likewise apparent. *N. perdicaria* and *N. cinerasens* are closely related, possibly of less than specific rank, while *N. pentlandii pentlandii* and *N. pentlandii oustaleti* belong to a different species.

Nothura boraquira is a very distinct species. If the genus *Nothura* is divided into groups, *boraquira* would constitute one and the remaining species would compose the other. The distribution of *Heptapsogaster boliviana* (Carriker) on *Nothura darwinii* and *Heptapsogaster minor* Hopkins on *N. maculosa* distinguishes these two bird species. *N. chacoensis* and *N. minor* are closely related to *N. maculosa* but a statement as to their precise relationships requires the study of additional material.

Little can be added to the knowledge of *Eudromia* and *Tinamotis* from the study of the distribution of Mallophaga except to state that two species are definitely recognizable in each genus, *Eudromia elegans* and *E. mira* and *Tinamotis pentlandii* and *T. ingoufi*.

Many of the relationships observed in this present study may not be in agreement with those postulated by ornithologists in their papers on the classification of the tinamous. However, the agreement is remarkably close between the distribution of Mallophaga and that of their hosts. Studies of this sort involving the analysis of interspecific relationships can contribute to a more thorough understanding of the evolution of many groups.

SUMMARY

Several thousand specimens of Mallophaga have been studied from 130 of the 140 known species and subspecies of tinamous. 18 of the 20 Mallophaga genera parasitizing this host order are restricted to it. The generic nomenclature used is that of Hopkins and Clay (1952) with the following exceptions: *Austrokelloggia*

Carriker = *Kelloggia* Carriker, *Heterogoniodes* Carriker = *Megapeostus* Carriker, and *Heptapsus* Carriker = *Pterocotes* Ewing. An analysis of the segmentation of the heptapsogastrid pterothorax and abdomen indicates that the Heptapsogastridae can no longer be considered distinct from the Philopteridae. In this group of Mallophaga, there is a parallel between a primitive pterothorax and abdomen of the parasite and the phylogenetic position of the host.

An analysis of the distribution of Mallophaga genera on their hosts indicates that they can be used to distinguish host categories of greater than generic rank. The inclusion of *Crypturellus*, *Tinamus* and *Nothocercus* in the Tinaminae, *Rhynchotus*, *Taoniscus*, *Nothura* and *Nothoprocta* in the Rhynchotinae and *Tinamotis* and *Eudromia* in the Eudromiinae is justifiable by the parasite data.

The Mallophaga species groups define host genera and provide exact data on their relationships. Von Boettischer's classification (1934) with one exception conforms perfectly to the divisions depicted by the tinamou lice. Parasite distribution indicates that *Crypturellus* and *Nothocercus* are more closely allied than either one is with *Tinamus*.

Data from taxonomic studies of the approximately 200 species of lice parasitizing the tinamous has been used to ascertain the relations of the parasites. These relationships have been compared with an accepted classification (Hellmayr and Conover, 1942) of the host species. The amount of agreement between these lice and their hosts is very high. The usual situation is one of a 1:1 correspondence between host and parasite species. In a few instances, a species of Mallophaga is found on a group of closely related species which may actually be a polytypic species. A section on aviparasitological conclusions serves to present those findings of ornithological significance. By the use of Mallophaga, many of the relationships among species of tinamous which were poorly known or speculative have been confirmed or denied by this technique.

REFERENCES CITED

Boettischer, Hans von. 1934. Beiträge zu einem phylogentisch begrundeten naturlichen System der Steisshuhner (Tinami) auf Grund einer taxonomisch verwertbaren Charaktere. Jena Zeits. Naturwiss. 69: 169–92, 1 fig.

Carriker, M. A., Jr. 1936. Studies in neotropical Mallophaga, Part I. Lice of the tinamous. Proc. Acad. Nat. Sci. Philadelphia 88: 45–218, 32 pls.

1944. Studies in neotropical Mallophaga (III) (Tinamidae No. 2). Proc. U. S. Nat. Mus. 95(3180): 81–233, 29 figs.

1945. Neotropical Mallophaga miscellany No. 1. Bol. Ent. Venezolana 4(4): 165–89, 21 figs.

1953a. Studies in neotropical Mallophaga. XII, Part 1. Lice of the Tinamous. Rev. Brasil. Biol. 13(3): 209–24, 23 figs.

1953b. Studies in neotropical Mallophaga. XII, Part 2. Lice of the Tinamous. Rev. Brasil. Biol. 13(4): 325–46, 31 figs.

1954. Report on a collection of Mallophaga, largely Mexican (Part 1). Florida Ent. 37(4): 191–207, figs. 8–24.

1955a. Studies in neotropical Mallophaga. XII, Part 3. Lice of the Tinamous. Bol. Ent. Venezolana 11(½): 1–28, 6 pls.

1955b. Studies in neotropical Mallophaga. XII, Part 4. Lice of the Tinamous. Bol. Ent. Venezolana 11(¾): 1–35, 18 figs.

Chandler, A. C. 1916. A study of the structure of feathers with reference to their taxonomic significance. Univ. California Publ. Zool. 13(11): 243–446.

Clay, Theresa. 1937. Mallophaga from the Tinamidae. Proc. Zool. Soc. London (B) 107: 133–59, 4 pls., 14 figs.

1940. Genera and species of Mallophaga occurring on gallinaceous hosts. II, *Goniodes*. Proc. Zool. Soc. London (B) 110: 1–120, 79 figs.

1943. Bird lice from the Tinamidae. Zool. Ser., Field Mus. Nat. Hist., 24(33): 375–387, figs. 31–35.

1946. Mallophaga Miscellany—No. 3. Ann. Mag. Nat. Hist. (11)13: 355–9, 1 fig.

1950. Some problems in the evolution of a group of ectoparasites. Evolution 3(4): 279–99, 4 figs., 9 tab.

1954. The post-spiracular seta and sensillus in the Mallophaga (Insecta). Ann. Mag. Nat. Hist. (12)7: 716–8, 2 figs.

1956. Personal communication.

Conover, Boardman. 1949. A new species of *Tinamus* from Peru. Fieldiana: Zool. 31: 263–6, fig. 66–67.

1950a. A study of the spotted tinamous. Genus *Nothura*. Fieldiana: Zool. 31: 339–62.

1950b. A study of the elegant tinamous. Genus *Eudromia*. Fieldiana: Zool. 31: 363–74.

Glenny, F. H. 1946. A systematic study of the main arteries in the region of the heart. Aves. XI. Tinamiformes—with some notes on their apparent relationship with the Galliformes. Canad. Jour. Res. (D) 24: 31–38, 3 figs.

Guimarães, L. R. 1936. Contribuição para o conhecimento das Mallophagas das aves do Brasil. V. Folia Clin. Biol., São Paulo, 8: 48–50, 1 fig.

1942a. Sôbre alguns géneros e espécies de Heptapsogastridae (Mallophaga)—I. Papéis Avulsos Dept. Zool. São Paulo, 2(2): 15–37, 31 figs.

1942b. Sôbre alguns gêneros e espécies de Heptapsogastridae (Mallophaga)—II. Papéis Avulsos Dept. Zool., São Paulo, 2(12): 151–70, 14 figs.

1942c. Sôbre as espécies do gênero *Pseudolipeurus* (Mallophaga—Philopteridae). Papéis Avulsos Dept. Zool., São Paulo, 2(20): 267–90, 23 figs.

1943. Sôbre alguns gêneros e espécies de Heptapsogastridae (Mallophaga)—III. Papéis Avulsos Dept. Zool., São Paulo, 3(2): 19–38, 19 figs.

1944a. Sôbre os Menoponidae (Mallophaga) encontrados em Tinamiformes. Papéis Avulsos Dept. Zool., São Paulo, 4(8): 105–16, 16 figs.

1944b. Alguns Philopteridae (Mallophaga) de Tinamiformes. Papéis Avulsos Dept. Zool., São Paulo, 6(19): 209–20, 17 figs.

1946. Nova espécie de *Rhopaloceras* (Heptapsogastridae—Mallophaga). Livro de Homenagem a R. F. d'Almeida, São Paulo, Art. 21: 211–17, 8 figs.

1947a. Notas sôbre *Microctenia* (Menoponidae—Mallophaga) e descrição de uma nova subespécie. Papéis Avulsos Dept. Zool., São Paulo, 8(16): 197–202, 3 figs.

1947b. Pequenas notas sôbre Malófagos. I. Papéis Avulsos Dept. Zool., São Paulo, 8(22): 261–3.

1948. Sôbre algunas espécies de Malófagos encontrados em *Tinamus tao tao* Temminck e *Tinamus tao septentrionalis* Brabourne e Chubb. Bol. Mus. Paraense E. Goeldi 10: 161–73, 8 figs.

1950a. Sôbre alguns gêneros e espécies de Heptapsogastridae (Mallophaga)—V. Papéis Avulsos Dept. Zool., São Paulo, 9(16): 249–58, 3 figs.

1950b. Pequenas notas sôbre Malófagos. II. Pepéis

Avulsos Dept. Zool., São Paulo, 9(21): 321–40, 1 fig., 9 tab., 3 graphs.

1953. Sôbre alguns gêneros e espécies de Heptapsogastridae (Mallophaga)—IV. Arq. Mus. Nac., Rio de Janeiro, 42: 233–54, 5 pls.

Guimarães, L. R., and **Frederico Lane.** 1937. Contribuições para o conhecimento das Mallophagas das aves do Brasil. VI. Rev. Mus. Paulista 23: 1–21, 5 pls.

Hellmayr, C. E., and **Boardman Conover.** 1942. Catalogue of birds of the Americas and the adjacent islands. Zool. Ser., Field Mus. Nat. Hist., 13 (Pt. I, No. 1). vi+636 pp.

Hopkins, G. H. E., and **Theresa Clay.** 1952. A check list of the genera and species of Mallophaga. London: British Museum (Natural History). 362 pp.

Kéler, Stefan von. 1938. Über brasilianische Mallophagen. 1. Beitrag. Arb. Morph. Taxon. Ent., Berlin, 5(4): 305–26, 11 figs.

1939a. Über brasilianische Mallopagen. 2. Beitrag. Arb. Morph. Taxon. Ent., Berlin, 6(3): 222–53, 23 figs.

1939b. Baustoffe zu einer Monographie der Mallophagen. II. Teil: Überfamilie der Nirmoidea (1). Nova Acta Acad. Leop.-Carol. (n.F.) 8(51): 1–254, 4 pls., 114 figs.

Lambrecht, Kálmán. 1933. Handbuch der Palaeornithologie. Berlin: Gebruder Borntraeger. xix+1024 pp., 209 figs., 4 pls.

McDowell, Samuel. 1948. The bony palate of birds. I. The Palaeognathae. Auk 65: 520–49, 6 figs.

Mayr, Ernst, and **Dean Amadon.** 1951. A classification of recent birds. Amer. Mus. Nat. Hist. Novitates No. 1496: 1–42.

Miranda-Ribeiro, Alípio de. 1938. Notas ornithologicas (XIII). Tinamidae. Rev. Mus. Paulista 23: 667–788, 18 pls.

Peters, J. L. 1931. Check-list of birds of the world. Cambridge: Harvard Univ. Press. xviii+345 pp.

Romer, A. S. 1945. Vertebrate Paleontology, 2d Edition. Chicago: Univ. Chicago Press. viii+687 pp.

Rothschild, Miriam, and **Theresa Clay.** 1952. Fleas, flukes and cuckoos. London: Collins Son and Co., Ltd. xiv+485 pp.

Todd, W. E. C. 1942. List of tinamous in the collection of the Carnegie Museum. Ann. Carnegie Mus. 29: 1–29.

Ward, R. A. 1957. A study of the host distribution and some relationships of Mallophaga (Insecta) parasitic on the Tinamiformes (Aves). Part 2. Ann. Ent. Soc. America, in press.

Wetmore, Alexander. 1951. A revised classification for the birds of the world. Smithsonian Misc. Coll. 117: 1–22.

Wetmore, Alexander, and **W. H. Phelps, Jr.** 1951. Observations on the geographic races of the tinamou *Crypturellus noctivagus* in Venezuela and Colombia. Bol. Soc. Venezolana Cienc. Nat. 13: 115–19, 1 map.

Wilson, F. H. 1936. The segmentation of the abdomen of *Lipeurus heterographus* Nitzsch (Mallophaga). Jour. Morph. 60(1): 211–19, 5 figs.

THE PHYLOGENY AND SYSTEMATICS OF THE FAMILY THAUMASTOCORIDAE (HEMIPTERA: HETEROPTERA)[1]

CARL J. DRAKE

Smithsonian Institution, Washington, D. C.

AND

JAMES A. SLATER

Department of Zoology and Entomology, University of Connecticut, Storrs, Connecticut

The recent acquisition of considerable unworked material from several museums together with our personal collections in the little known family Thaumastocoridae has led us to review the taxonomic relationships within the family, to characterize two new genera and seven new species, and to investigate the systematic and phylogenetic position of the family.

The Thaumastocoridae were first described by Kirkaldy (1908) as a subfamily of Lygaeidae, based upon a new genus founded for the reception of a new species from Australia. Bergroth (1909) erected a second genus for a second species from Tasmania, amplified the original diagnosis of the group, and commented upon the presumed antiquity of these singular insects. He followed Kirkaldy's classification and retained the group within the Lygaeidae. Reuter (1912) elevated the Thaumastocoridae to the status of a family and based on them a distinct new phalanx within his series Onychiophora. Barber (1920) characterized the first genus and species from the western hemisphere, which he made the basis for the creation of a new subfamily. In this latter paper, the higher groups within the family were redefined and their phylogenetic characters were discussed. These papers constituted all of the original contributions of a systematic nature to the family until Kormilev (1955) recently founded a new subfamily and new genus for a new species from Argentina. The affinities of this form are discussed below.

In this paper the literature on the family is reviewed. The absence of trichobothria and the asymmetry of the male genitalia are noted as indicating that the Thaumastocoridae belong to the Cimicomorpha of Leston, Pendergrast, and Southwood (1954) rather than to the Pentatomomorpha where they have previously been assigned. The cimicomorph relationship of the family is further evidenced by the hind wing having radius and media fused beyond the basal cell (Plate 1: 17), by the lack of an ectodermal spermatheca, and by the structure of the eggs

[1]Accepted for publication Oct. 30, 1956.

which lack micropylar processes but have a true operculum bearing follicular pits (Plate 1: 9). The systematic position of the Thaumastocoridae within the cimicomorph complex is less evident. Both Kirkaldy (1908) and Kormilev (1955) noted their general anthocorid-like appearance.

The opinion of Bergroth (1909) that the thaumastocorids represent very ancient insects obviously influenced Reuter (1912) in his systematic placement of the group. It is interesting to note in passing that Reuter, who was blind at that time, never actually saw a specimen of the family. Before we attempt to analyze the relationships and phylogeny of these peculiar insects, it seems advisable to comment briefly upon their previously ascribed primitive nature.

Of the characters mentioned as primitive by Reuter (1910, p. 37), the Thaumastocoridae possess the following: 1) presence of ocelli; 2) Four-segmented antennae; 3) Four-segmented labium (Plate 1: 7); 4) Front wing divisible into three primary units, the clavus, corium and membrane (Text figs. 1 and 2); 5) Metasternum with scent gland openings (Plate 1: 14); 6) Homomorphous pairs of legs; 7) Lack of arolia, in one subfamily; 8) ventral spiracles. On surveying these characters it is evident that, with the possible exception of the arolia, their occurrence is so widespread through many heteropterous families that they are of little value, if any, in ascertaining whether one is dealing with a group of generally specialized species or a more primitive type of insect.

The characteristics which Reuter regarded as specialized conditions are represented in the Thaumastocoridae as follows: 1) Lack of venation in the membrane of the front wing; 2) Separate mesosternum and metasternum (Plate 1: 14); 3) Reduction of the metasternal scent gland opening; 4) Trochalopodous hind coxae; 5) Reduction of the tarsal segments from three to two (Plate 1: 8, 13); 6) Occurrence of arolia; 7) Absence of an ovipositor (Plate 2: 10); 8) Dissimilar male genital parameres; 9) reduction of the nymphal scent glands from three to two or one. In addition to the above characters, the features that we consider significant specializations are the marked asymmetry of the ninth abdominal segment of the male, loss of parameres (either one or both), modifications of the basal labial segments, jugal enlargements, and the absence of an ectodermal spermatheca.

While the evidence presented above is conflicting to some extent, it seems evident that the marked structural modifications of the external genitalia in both sexes, together with important external features, indicate that the Thaumastocoridae are highly specialized and that there is no valid evidence to support the hypothesis that we are dealing in any indicative manner with a primitive or homotenous group.

MORPHOLOGICAL FEATURES

The morphological features of the Thaumastocoridae that are of major importance in understanding the systematic and phylogenetic relationships of the family are as follows.

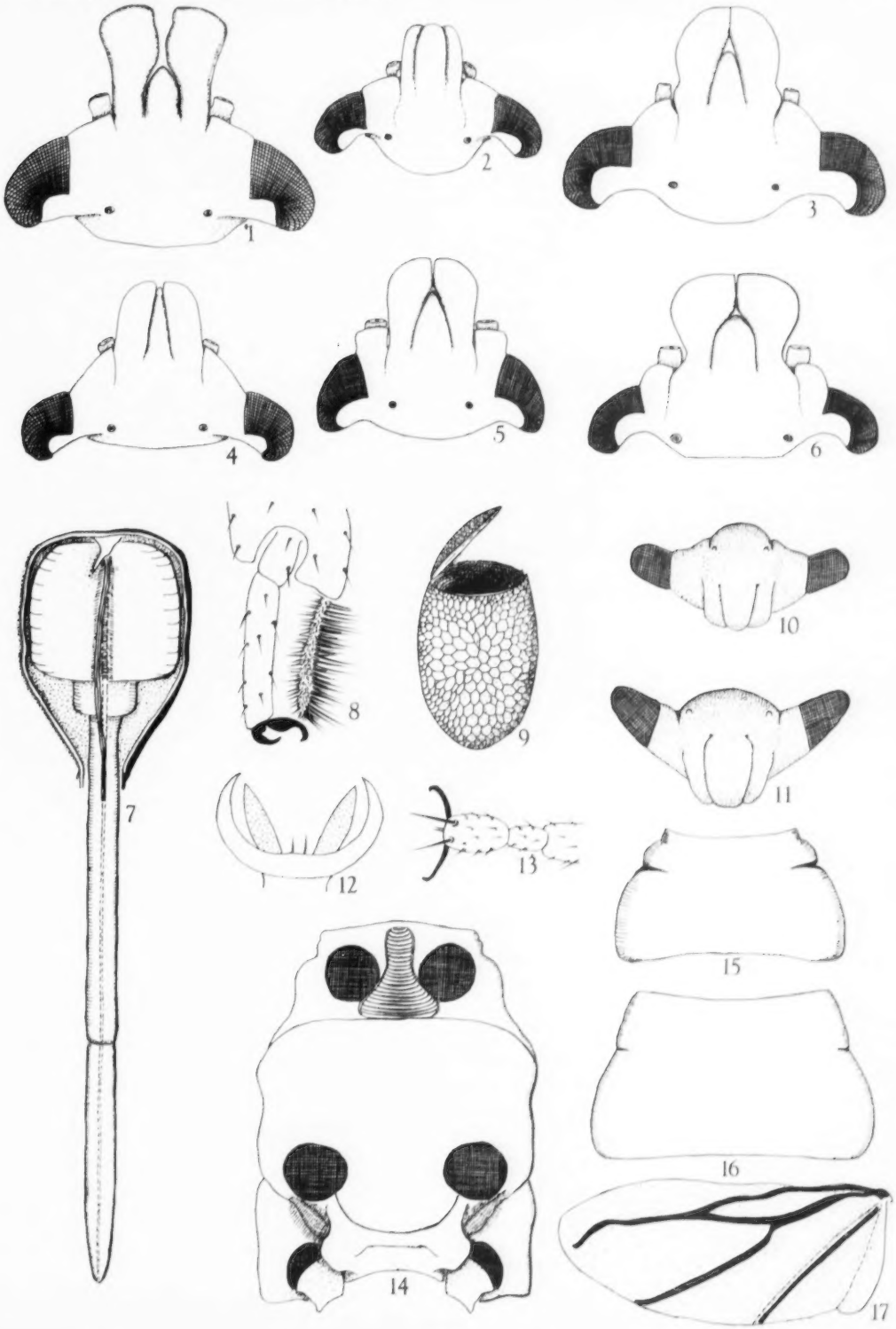
Male genitalia. Throughout the family the ninth abdominal segment is highly asymmetrical (Plate 2: 1, 6, 8, 11). This asymmetry is so strongly developed that it affects the preceding segment or segments; and in *Xylastodoris*, at least, it has resulted in modification of segments five, six, and seven to accomodate the ninth segment (Plate 2: 6). Members of the subfamily Thaumastocorinae are much less specialized in this regard. In these species the genital capsule itself is always extended into a prong-like projection (Plate 2: 8, 11) which perhaps functions, together with the single paramere characteristic of this subfamily, in spreading apart the orifice of the female genital chamber during copulation. Curiously, some species are modified so that the opening of the genital capsule is to the right side (Plate 2: 8), while in others the modification turns the opening to the left side (Plate 2: 11). Relatively few specimens of most species in this subfamily have been available for examination, but modification seems to be consistently dextral or sinistral for any given species. The phallus is difficult to interpret without fresh material, but it appears to be divisible into ***phallotheca***[2] and ***endosoma***. The endosoma, however, is not further subdivided into conjunctiva and vesica. Examination of fresh material would be highly desirable here.

In *Xylastodoris* further specialization has occurred. Both the parameres are lacking, and

[2]Terminology of genital structures follows that of Dupuis (1955).

EXPLANATION OF PLATE 1

1. *Baclozygum depressum* Bergroth, dorsal view of head.
2. *Onymocoris hackeri* n. sp., dorsal view of head.
3. *Thaumastocoris hackeri* n. sp., dorsal view of head.
4. *Onymocoris izzardi* n. sp., dorsal view of head.
5. *Thaumastocoris petilus* n. sp., dorsal view of head.
6. *Thaumastocoris australicus* Kirkaldy, dorsal view of head.
7. *Onymocoris hackeri* n. sp., ventral view of labium.
8. *Thaumastocoris hackeri* n. sp., tarsus and apex of tibia, showing lobate sensory appendage.
9. *Thaumastocoris hackeri* n. sp., egg.
10. *Onymocoris barberi* n. sp., cephalic view of head.
11. *Onymocoris hackeri* n. sp., cephalic view of head.
12. *Xylastodoris luteolus* Barber, apex of tarsus, showing claws, arolia, and pseudarolia.
13. *Xylastodoris luteolus* Barber, tarsus, apex of tibia, and claws.
14. *Thaumastocoris hackeri* n. sp., ventral view of thorax, showing prosternal stridulatory sulcus and metasternal scent gland channel.
15. *Onymocoris barberi* n., sp., dorsal view of pronotum.
16. *Onymocoris izzardi* n. sp., dorsal view of pronotum.
17. *Baclozygum depressum* Bergroth, hind wing.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

the ninth segment itself has become elongate and tapering so as to form a sheath around the long slender phallus. It is quite possible that the extension of the genital capsule may actually enter the female orifice during copulation. In *Xylastodoris luteolus* some specimens have the genital capsule modified to open to the left side, while in others the asymmetry is diametrically reversed so that the opening of the capsule is to the right. Thus one condition appears as a mirror image of the other. Knowledge of the origin a .d genetic mechanism involved in such asymmetry would be of great scientific interest. The wide orifice and the simple sac-like appearance of the female genital chamber indicates that the male could effect coitus equally well from either the left or the right side. Thus, with our present limited knowledge, there is no apparent selective advantage to either direction of male asymmetry.

Although no detailed study of *Discocoris* has been made, both the parameres appear to have been lost. According to Kormilev (1955), the opening of the male genital capsule of *Discocoris vianai* is most commonly to the right, only about one specimen in fifty having the capsule turned to the left side.

Female genitalia. The female external genitalia (Plate 2: 10) show marked reduction. The ovipositor is entirely lacking, both gonopopyses and gonocoxites being absent. There is no evidence of a spermatheca: if a sperm storage organ occurs at all in these insects it is thus of mesodermal origin. The genital chamber is large and sac-like, with a very broad orifice. The eighth sternite is represented by paired lateral plates. The ninth tergite is curved ventrad at the apex of the abdomen so that the terminal portion is ventral.

Mouthparts. The labium (Plate 1: 7) is four-segmented in this family, although Barber (1920) and Kormilev (1955) both state otherwise. The first labial segment is quite short and usually is much broader than the succeeding segments. The stylets appear habitually to lie free from the labial sheath of the first (and probably also the second) segment. This occurs so frequently in our mounted material that it is probably their normal position and not a consequence of preservation. The bucculae are high, very broadly separated, and in most species converge caudad. The condition described here constitutes a diagnostic characteristic of the family.

Head. A pair of ocelli is always present. The compound eyes are usually pedunculate and strongly reminiscent of the condition in the lygaeid subfamily Geocorinae, but this is not the case in the Xylastodorinae and it varies considerably in degree in the Thaumastocorinae. In many species the juga are greatly enlarged (Plate 1: 1, 3, 5, 6) and flaring, and this condition is often of considerable value in specific diagnosis. In the Xylastodorinae and the Australian genus *Onymocoris* the juga do not exceed the apex of the tylus. We consider this to represent the generalized condition, with specialization occurring through *Baclozygum* to the highly modified condition found in species of *Thaumastocoris*.

Tarsi. All members of the family possess two-segmented tarsi. In view of the other marked specializations of the family this too probably represents a specialized condition. However, it may be pertinent to note that since heteropterous nymphs generally possess two-segmented tarsi such a condition does not necessarily indicate specialization and may in many cases simply represent a neotenic phenomenon. Most previous controversies do not seem to consider the possibility of neoteny, a hypothesis which might well resolve some of the apparently conflicting evidence presented by this structural character.

In the Thaumastocorinae neither arolia nor pseudarolia are present (Plate 1: 8), but both are present in the Xylastodorinae (Plate 1: 12). In the former subfamily there is a peculiar flattened lobate structure extending from the apex of the tibiae. So far as we know, the only other occurrence of such a structure is in the nabid genus *Carthasis*. The "spongy fossa" of many Reduviidae may, however, be a homologous structure.

Wings. The hemelytron is composed of clavus, corium, and membrane, and is without any trace of a cuneus. The membrane shows no trace whatever of venation, which is certainly a very marked specialization. In the Xylastodorinae the corium is extended far back along the lateral margin of each hemelytron, reaching to, or almost to, the apex of the transparent membrane. When the wings are folded, the extensions of the two coria thus appear nearly to meet at the midline (see figures in Barber 1920 and Kormilev 1955). This condition too is certainly more specialized than that found in the Thaumastocorinae. We find it very useful as a subfamily distinction.

EXPLANATION OF PLATE II

1. *Baclozygum bergrothi* n. sp., ventral view of body. (Drawing by courtesy of Dr. W. E. China.)
2. *Thaumastocoris hackeri* n. sp., clasper.
3. *Onymocoris hackeri* n. sp., clasper.
4. *Thaumastocoris australicus* Kirkaldy, clasper.
5. *Thaumastocoris australicus* Kirkaldy, ventral view of male genital capsule.
6. *Xylastodoris luteolus* Barber, ventral view of terminal portion of abdomen.
7. *Onymocoris hackeri* n. sp., terminal portion of male genital capsule.
8. *Baclozygum depressum* Bergroth, ventral view of terminal portion of abdomen.
9. *Baclozygum depressum* Bergroth, lateral view (morphologically) of phallus. (Adapted from sketch by courtesy of Dr. W. E. China.)
10. *Thaumastocoris hackeri* n. sp., dorsal view of female genital region with tergum removed.
11. *Thaumastocoris hackeri* n. sp., ventral view of terminal portion of abdomen.

1
2
3
4
5
6
7
8
9
10
11

The hind wing (Plate 1: 17) is typically cimicomorph, with radius and media fused into a single vein beyond the basal cell. A single vannal vein is present (the "AI" of Kormilev 1955 is the vannal fold). The hamus and intervannals are absent. The appearance of the hind wing is, in fact, as in *Joppeicus* (China 1955). The absence of a hamus does not necessarily indicate a character divergent from that of the Anthocoridae as China (1955) seems to feel, for the presence or absence of a hamus has long been used as a subfamily character in that group by numerous authors, including Gross (1954). Furthermore, the hamus is present, absent, or incomplete within the Lygaeidae (Slater and Hurlbutt, in press).

Thorax. A well developed stridulatory sulcus is present in some species (Plate 1: 14). Usinger (1943) considers this character of major importance in separating the Phymatidae and Reduviidae, where the sulcus is present, from the Nabidae and Enicocephalidae, where it is absent. Even though the sulcus may at times be of importance phylogenetically, we are strongly inclined to feel that it represents an independent condition in the Thaumastocoridae and thus does not indicate reduvioid relationship. It may, of course, indicate specialization from the rather primitive nabid line.

The metasternal scent gland canals and orifices are present (Plate 1: 14) but reduced and perhaps not functional. We consider the mesothorax and metathorax to be non-composite but admit some doubt as to the definition of the condition as used by some authors.

Abdomen. In the Thaumastocorinae at least two median scent glands are present on the abdominal tergum between segments three and four, and four and five. In *Xylastodoris* there appears to be a very small unpaired gland remnant present between tergites three and four. The condition is specialized from the presumably three-paired gland condition of the generalized heteropteran, although it is possible a third gland is present in the Thaumastocorinae.

Spiracles are present on segments one through eight. The spiracles on the first segment are dorsal whereas the others are ventral.

The abdominal segments lack connexival sutures (usually present in reduvioids) and the mechanism of abdominal expansion is by dorso-ventral convexity through the presumed presence of intersegmental membranes as in the Cimicidae (see Davis 1956).

PHYLOGENETIC POSITION

Speculation as to the position of the Thaumastocoridae within the Cimicomorpha is of considerable interest. The publications of Reuter (1910, 1912), Usinger (1943), and several papers of China, China and Myers, and Carayon have proven valuable guides. We have utilized their conclusions to a considerable extent.

In the aggregate their characters strongly support the placing of the Thaumastocoridae in the Cimicoidea. The asymmetry of the male genitalia, the lack of paired pseudospermathecae, the lack of connexival sutures, the presence of ostiolar canals, the presence of pseudarolia in some forms all militate against a reduvioid relationship.

Within the Cimicoidea there appear to be at least two primary evolutionary lines, the anthocorid and the mirid. The evidence appears largely to substantiate an anthocorid relationship for this family. China and Myers (1929) emphasized the value of the indefinable "habitus" in determining relationships. It is perhaps significant in this regard to note that Kirkaldy (1908) and Kormilev (1955), working with very different forms, both mentioned the anthocorid-like appearance of these insects. However, we should be inclined to regard the habitus of *Discocoris* as more isometopid-like.

In the Thaumastocoridae the head is straight, with a long gula, as in the Anthocoridae, whereas in the Miridae the head is generally deflexed and the gula is short, except in the primitive Cylapinae and a few other forms (see China and Myers 1929). The presence of ocelli is distinctly anthocoroid rather than miroid. The shortened first labial segment, if at all significant here, again supports an anthocorid relationship, as does the absence of basal cells in the membrane of the hemelytron. While two-segmented tarsi as such appear in both groups, as China and Myers have heretofore pointed out, it is usual in the Miridae to find the first segment long and the second short in such cases, whereas in anthocorid-like types the reverse is true. In the Thaumastocoridae the basal tarsal segment is always much shorter than the second (Plate 1: 8), suggestive of anthocorid relationships.

The presence of arolia and pseudarolia in one subfamily and their absence in the other might seem to support China's contention that these structures are relatively plastic adaptive features. Certainly they are of no value in interpreting the affinities of this family.

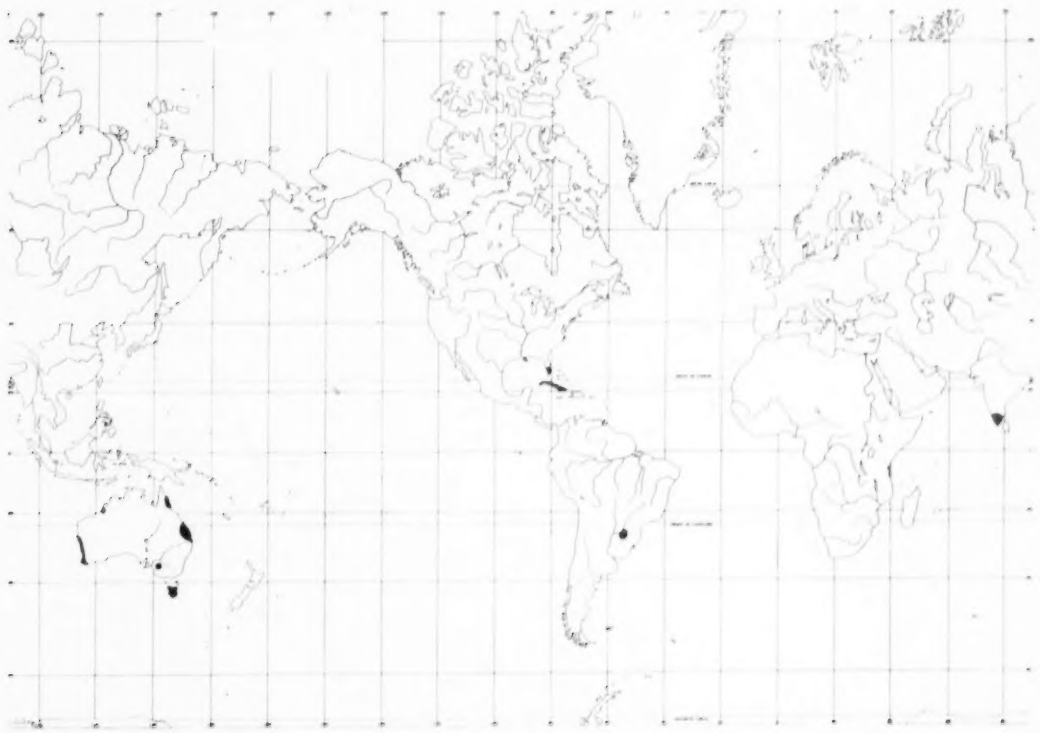
The condition of the male and female genitalia, we feel, is of fundamental value in establishing the affiliations of the Thaumastocoridae. Here the evidence for anthocorid relationship is very marked. In female anthocorids the lack of an ovipositor is of frequent occurrence whereas mirid groups have a well developed oviposition apparatus. The male genitalia of anthocorids show strong asymmetry, with attendant reduction and loss of a paramere and specialization of the remaining one. The Cimicidae, of course, also possess a single paramere. In the Thaumastocoridae not only is there a high degree of asymmetry and loss of a paramere, but in one subfamily further specialization from this condition has led to the loss of both parameres.

The obsolete condition of the metasternal

scent gland orifices is also more indicative of anthocorid than mirid relationships.

In conclusion, we believe that the Thaumastocoridae are Cimicoidea rather closely related to the Anthocoridae and have diverged from the main anthocorid-cimicid line after the appearance of asymmetry in the male genitalia occurred in the phylogeny of the group.

Furthermore, morphological evidence fails to support any serious consideration of these insects as primitive, but rather establishes them as very specialized forms. The zoogeographic picture (Text fig. 3) which previously gave the appearance of great antiquity now becomes much less impressive by virtue of the discovery of species in southern India and in subtropical Argentina.



Text figure 3. World distribution of the family Thaumastocoridae. (Base map by courtesy of The Hammond Company.)

THE FAMILY NAME

The correct name to be applied to this family has been subject to differences of interpretation in the past. Kirkaldy (1908) in his original diagnosis of the group (p. 777) used the name Thaumastotheriinae, based upon the generic name *Thaumastotherium*. However, in the plate facing page 788 he labeled his figures "*Thaumastocoris* (*Thaumastotherium* in the text)." Furthermore, in a half sheet labeled "Corrigenda" in the original text appearing and bound between pages 768 and 769 (page priority), Kirkaldy states that Thaumastocorinae should be substituted for Thaumastotheriinae and *Thaumastocoris* for *Thaumastotherium*. *Thaumastocoris* was subsequently correctly used by Bergroth (1909) and accepted by Reuter (1912), Barber (1920), China (1933, 1955), and China & Miller (1955), among others. McAtee (1926) ineptly stated that Kirkaldy was unwarranted in changing the name in the original publication and that *Thaumastotherium* must be used. Costa Lima (1940) and Kormilev (1955) also accepted the latter name as the proper one.

In addition to Kirkaldy's "corrigenda" this case appears to be clearly covered by the provisions of Article 19 as revised in the Copenhagen Decisions on Zoological Nomenclature. Thus on pages 43–44, paragraph (1), (a), (ii), it is stated that where there is more than one original spelling and neither is an inadvertent error the valid original spelling is the one employed by the first subsequent user. In this instance it is patent that the first subsequent user was Bergroth (1909), and since he used *Thaumastocoris* this then

became the "valid original spelling." *Thaumastotherium* under the Règles is known as an "invalid original spelling" as defined in the Copenhagen Decisions, 1953, p. 44, paragraph 71 (1) (b) (iii).

BIOLOGY AND DISTRIBUTION

Very little is recorded in the literature regarding the habitats and habits of genera and species of the family Thaumastocoridae. The areas known to be inhabited by the various members of the family are plotted on the accompanying map (Text fig. 3), which charts the distribution of the species from records in the literature and from the locality labels of the specimens upon which the present paper is based.

Of the six genera and eleven species comprising the present study, two genera and seven species are characterized herein as new to science. As the number of new species is nearly double that of the ones previously known, the authors are fully aware that much more field collecting, recording of host plants, study of feeding and breeding habits, and ecological and taxonomic work yet remains to be done. The widely discontinuous present distribution of the family indicates that the ancestral history is a complex one, and it would be presumptuous to draw many conclusions at this time. However, if the present picture is at all significant, the distribution of the family in Australia, Southern India, Argentina, and the Greater Antilles appears to be that of a relict group—although, as previously indicated, certainly not a primitive one.

Host Plants. Up to the present time the food plants of only two species, both members of the American subfamily Xylastodorinae Barber, have been listed in the literature. These two species feed and breed on the newly developing and unfolding terminal leaves of palm trees, *Xylastodoris luteolus* Barber on the Royal Palm (*Oreodoxa regia* H. B. & K.) and *Discocoris vianai* Kormilev on "Palmito" (*Euterpe edulis* Mart.). Only one of the old world species before us bears a possible host plant indication. *Onymocoris hackeri*, n. g., n. sp., was collected in some numbers by beating Australian evergreens (*Banksia* sp.). Because of the paucity of host and other data, it seems unwise to draw definite conclusions or to indicate by analogy possible dispersal patterns more or less paralleling those of host plant distributions. Our knowledge of the natural geographic range of species and of genera is thus probably very incomplete.

Family **Thaumastocoridae** Kirkaldy 1908

Thaumastocorinae Kirkaldy 1908: Corrigenda and Plate 43; Bergroth 1909: 331.
Thaumastotheriinae Kirkaldy 1908: 777.
Thaumastocoridae, Reuter 1912: 10, 29–31, and 58; Barber 1920: 98–102; Blatchley 1926: 444–445; China 1933: 195; Poisson 1951: 1786; China 1955: 368; China and Miller 1955: 260.
Thaumastotheriidae, McAtee 1926: 14; Costa Lima 1940: 124; Kormilev 1955: 5–7.

Head straight or moderately deflexed, juga frequently exceeding tylus; ocelli present; antennae four-segmented; labium four-segmented, basal segment short and broad, stylets free from labial sheath basally, bucculae very broad, converging caudad; metasternal scent gland orifices present, but probably obsolete; metacoxae trochalopodous; legs homomorphous, femoral spines lacking; tarsi two-segmented, basal segment shorter than second, arolia and pseudarolia either present or absent; hemelytra consisting of clavus, corium, and membrane, claval commissure well developed, membrane without veins; hind wing with R+M fused beyond basal cell, hamus and intervannals absent, one vannal present; abdomen with eight pairs of spiracles, the posterior seven ventral; connexivum and connexival sutures absent; dorsal scent glands one or two, between abdominal tergites 3–4 and 4–5; ovipositor absent; female with eighth abdominal sternite reduced to paired lateral sclerites; true ectodermal spermathecae absent; male ninth abdominal segment strongly asymmetrical, with either one only or no parameres present; endosoma without distinct vesica; eggs with opercular cap, but without distinct micropylar processes.

Type genus: *Thaumastocoris* Kirkaldy 1908.

KEY TO SUBFAMILIES OF THAUMASTOCORIDAE

1. Pseudarolia absent; apex of tibiae bearing a lobate sensory appendage; males with one paramere present, genital capsule with a lateral projection; apex of corium remote from posterior tip of membrane . . . . . **Thaumastocorinae** Kirkaldy
   Pseudarolia present; apex of tibiae without a lobate sensory appendage; males without parameres, genital capsule without a lateral projection; lateral margin of corium extending back nearly to apex of membrane . . . . . **Xylastodorinae** Barber

Subfamily **Thaumastocorinae** Kirkaldy 1908

Thaumastocorinae Kirkaldy 1908: Corrigenda and Plate 43; Bergroth 1909: 331; Barber 1920: 102.
Thaumastotheriinae Kirkaldy 1908: 777; Kormilev 1955: 6.
Thaumastocoridae, Reuter 1912: 10, 29–31, and 58.

Juga frequently surpassing tylus, eyes often pedunculate; tarsal segments very small, linear, arolia and pseudarolia absent; apex of tibiae bearing a lobate sensory appendage; males always with one paramere present; genital capsule of male with a lateral prong-like extension fitting into notch of eighth abdominal sternite.

Type genus: *Thaumastocoris* Kirkaldy 1908.

Known distribution: Australia, Tasmania, South India.

KEY TO THE GENERA OF THAUMASTOCORINAE

1. Labium relatively elongate, extending well onto mesosternum; juga convex, little if at all surpassing apex of tylus, thus never convergent anteriorly . . . . . **Onymocoris** new genus
   Labium much shorter, at most only reaching posterior margin of prosternum; juga frequently

exceeding apex of tylus, often convergent anteriorly 2

2. Antero-lateral pronotal angles often sharply angled but lacking a short, outwardly directed tubercle . . 3
Antero-lateral pronotal angles each bearing a short, outwardly directed tubercle . . . **Wechina** new genus

3. Juga convex, longitudinally tectiform, exceeding tylus but not in contact with one another anteriorly or only narrowly so; anterior curvature of eye meeting adjacent area of head in a continuous smooth line (Plate 1: 1) . . . . **Baclozygum** Bergroth
Juga flattened or excavated dorsally, more or less strongly ampliated, greatly surpassing and broadly convergent before tylus; anterior curvature of eye meeting adjacent area of head at a sharp angle (Plate 1: 3, 5, 6) . . . . . **Thaumastocoris** Kirkaldy

Genus **Onymocoris** new genus

Small, semi-depressed species; juga convex, not at all or only feebly surpassing apex of tylus, thus never convergent anteriorly; labium long, extending well onto mesosternum; head deflexed, eyes strongly pedunculate; corium bearing hairs, sometimes strongly hirsute; femora slender, not or only slightly incrassate; membrane narrowly darkened adjacent to apex of corium; male genital capsule opening to left side (in specimens studied).

Type species: *Onymocoris hackeri*, new species.

This interesting new genus is thus far known only from Australia, where two of the new species are eastern and the third is known only from the north-west coast. By virtue of the simple juga, long labium, and moderately depressed bodies these insects appear to be the most generalized forms in the family.

KEY TO THE SPECIES OF ONYMOCORIS

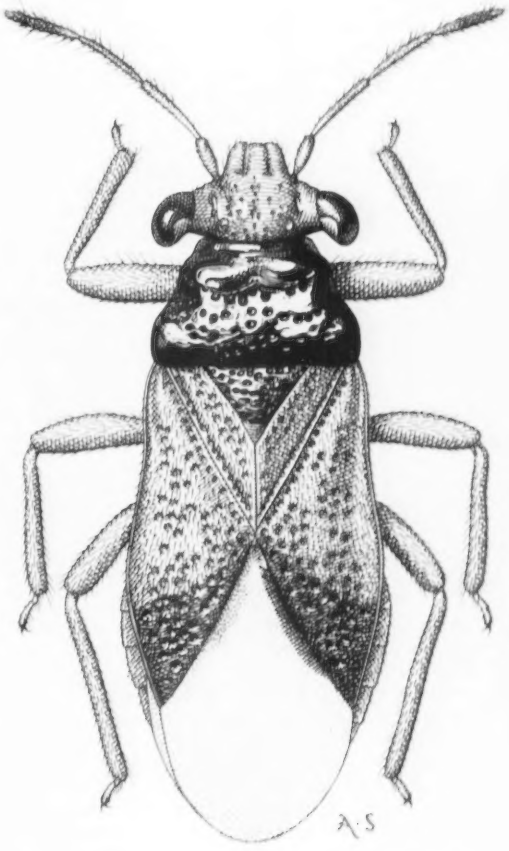
1. Pedunculate eyes strongly upcurved, extending upward as far as vertex in cephalic view (Plate 1: 11); pronotum dark castaneous to chocolate brown, thus strongly contrasting with head and corium . . . . . **O. hackeri** new species
Pedunculate eyes extending nearly straight out laterally from head, not extended upward nearly as far as vertex in cephalic view (Plate 1: 10); pronotum concolorous with head and corium 2

2. Lateral margin of corium strongly sinuate, distinctly expanded beyond apex of claval commissure; pronotal calli very convex and protruding, so as to form sharply angled pronotal margins (Plate 1: 15); pubescence moderately thick, but somewhat upstanding, not silky in appearance . . . . . **O. barberi** new species
Lateral margin of corium straight or nearly so, at most very gently arcuate; calli not prominent, and not forming sharply angled pronotal margins (Plate 1: 16); dorsal surface thickly covered with closely appressed silky pubescence (Text fig. 2) . . . . **O. izzardi** new species

Onymocoris hackeri, new species

(Text Figure 1)

Head moderately deflexed anteriorly, stramineous with a slight tinge of brown; juga and tylus equally extended anteriorly, both convex above, eyes fuscous to reddish, strongly pedunculate, with both stalk and eye tilted upward and gently curved posteriorly (Plate 1: 11); length head .41 mm., width across eyes .65 mm. (.62–.68), interocular space .40 mm.; labium brownish, extending between middle coxae. Antennae slender, testaceous, shortly pilose, distal half of terminal segment brownish to fuscous, length antennal segments: I, .12 mm., II, .26 mm. (.25–.28), III, .25 mm. (.22–.27), IV, .25 mm. (.22–.28). Legs pale testaceous, provided with seta-like pubescence, femora very slightly swollen.



Text figure 1. *Onymocoris hackeri* n. sp., dorsal view.

Abdomen beneath brown to largely fuscous, thoracic sterna and pleura black-fuscous, moderately shining.

Pronotum black-fuscous, becoming testaceous on antero-mesal portion, strongly shining, very coarsely, deeply punctate behind calli, much wider posteriorly than across anterior margin (52: 29), sparsely clothed with whitish decumbent pubescence, posterior margin feebly convex, lateral margins sinuate, considerably narrowed from humeri to calli, thence very little convergent

anteriorly, "collar" constricted, short; pronotum punctate between collar and calli, the latter strongly swollen, impunctate, shining, convex behind, area between calli impressed; length pronotum .39 mm. (.35–.42), width pronotum at base .67 mm. (.62–.70). Scutellum triangular, concolorous with pronotum, punctures nearly as large and deep as those of pronotum, becoming rugose, wider at base than median length (25: 20), length scutellum .22 mm. Hemelytra testaceous, with apical portion of corium strongly contrasting blackish fuscous, feebly shining, densely clothed with whitish decumbent pubescence; corium with lateral margins sinuate, convexly broadened beyond basal third; membrane whitish, subopaque, narrowly margined with dark fuscous along corial margin; distance apex clavus-apex corium .60 mm. (.55–.65), distance apex corium-apex abdomen .42 mm. (.38–.52). Total length 2.11 mm. (1.98–2.25).

Holotype (male and ***allotype:*** Samsonvale QUEENSLAND, Australia, VIII–12–1928 (H. Hacker); in C. J. Drake collection. ***Paratypes:*** 2 males, 5 females, same data as holotype; 5 females, same locality, VIII–19–1928; 2 females, N. Pine River, QUEENSLAND; in British Museum (Natural History), United States National Museum, South Australian Museum, C. J. Drake, N. A. Kormilev, and J. A. Slater collections.

Nothing is known of the biology of this species, except that labels on two specimens state they were collected on ***Banksia*** sp.

The strongly contrasting color pattern (as depicted in the figure) in addition to the characters mentioned in the key will separate this strikingly marked species from its congeners.

We take pleasure in dedicating this species to Mr. H. Hacker, hemipterist, who has collected a number of important Australian species of Thaumastocoridae and other Hemiptera.

Onymocoris barberi, new species

Head pale stramineous, becoming brownish on either side next to eyes; eyestalks scarcely tilted upwards (Plate 1: 10); juga only faintly surpassing tylus, length head .42 mm., width across eyes .65 mm., interocular space .40 mm.; antennae slender, testaceous, rather densely provided with short pale hairs, with third (lightly) and fourth segments infuscate, length antennal segments I, .12 mm., II, .30 mm., III, .28 mm., IV, .25 mm. Labium brownish testaceous, scarcely reaching to middle of mesosternum. Legs testaceous with a slight brownish tinge, scantily provided with pubescent hairs. Body beneath blackish fuscous, with venter more brownish fuscous.

Pronotum brownish, sparsely covered with pale decumbent pubescence, rather coarsely shallowly punctate, moderately narrowing anteriorly before humeri, nearly flat between humeral angles, much wider at base than median length (55: 30); collar strongly constricted, coarsely punctate between collar and calli, the latter strongly, convexly, transversely swollen, impunctate, separated at middle by impressed pronotal surface; length pronotum .35 mm., width pronotum .65 mm.; scutellum brown, coarsely punctate, length .23 mm.; hemelytra brownish-testaceous, rather densely clothed with fine, pale, recumbent pubescence, corial margin convexly widened beyond basal fourth; membrane whitish, subopaque, margined basally adjacent to corium with dark fuscous, distance apex clavus-apex corium .52 mm., distance apex corium-apex abdomen .40 mm. Total length 2.03 mm.

Holotype (male): Mt. Tambourine, QUEENSLAND, Australia, V–5–1929 (H. Hacker), in C. J. Drake collection.

Distinguished from *O. hackeri* by its color and from *O. izzardi* by its very fine and inconspicuous pubescence, swollen calli, more convexly dilated corial margin of the hemelytra, and other characters as mentioned in the preceding key.

We take pleasure in dedicating this fine species to our friend and senior colleague Mr. H. G. Barber.

Onymocoris izzardi, new species

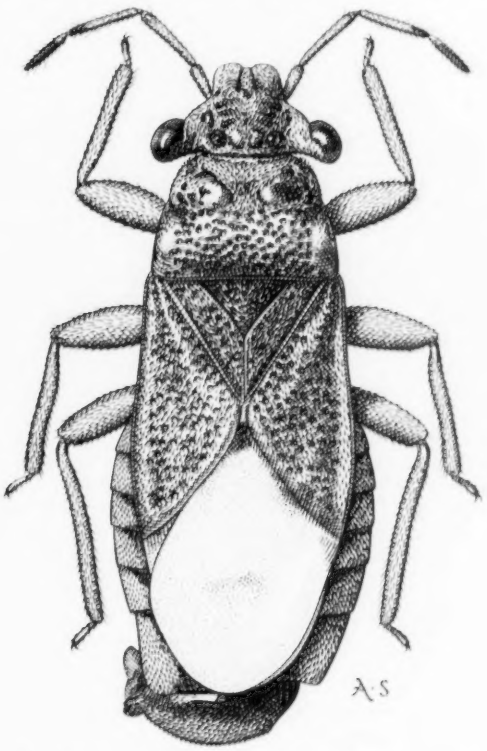
(Text Figure 2)

General coloration cinereous-stramineous with head and anterior portion of pronotum more brownish; abdomen beneath and above blackish, lateral margins of abdominal tergites brownish; pubescence dense, pale, silky, recumbent. Head with pubescence very thick and decumbent on median longitudinal line, outer margins of head, juga and eye stalks; the eye stalks scarcely tilted upwards, but distinctly curved backward; juga relatively broader and feebly exceeding tylus anteriorly. Length head .47 mm. (.42–.48), width of head across eyes .79 mm. (.78–.80), interocular space .50 mm. (.48–.52). Labium brownish testaceous, not quite reaching to middle of mesosternum. Antennae slender, slightly brownish testaceous, provided with pale pubescence, distal portion of third segment and all of fourth fuscous, length antennal segments I, .12 mm., II, .29 mm., III, .30 mm. (.25–.33), IV, .24 mm. (.22–.25). Legs slightly brownish testaceous, tarsi infuscate, provided with short pale pubescence, femora moderately swollen.

Pronotum only slightly narrowed anteriorly, lateral margins rounded, much wider at base than median length, with median length and apical width nearly equal (40: 39), coarsely punctate between and behind calli; calli moderately, transversely, convexly elevated, concave behind, impunctate; length pronotum .45 mm. (.42–.48), width prontoum .78 mm. (.75–.80). Scutellum dark, coarsely punctate, on same level as clavus, length .25 mm. (.22–.28). Hemelytra not as wide as abdomen, corial margin at most feebly widened beyond basal two-fifths; membrane whitish, subopaque, margined with dark fuscous

at base along apical margin of corium and with a prominent brownish band or patch in center. Distance apex clavus-apex corium .53 mm. (.50–.58), distance apex corium-apex abdomen .64 mm. (.60–.68). Total length 2.45 mm. (2.35–2.57).

Holotype (male) and *allotype*: Beverley, WESTERN AUSTRALIA (W. A. Lea); in British Museum (Natural History). *Paratypes*: 1 female, same data as holotype; WESTERN AUSTRALIA: 1 male, Yanchep (32 mi. N. of Perth), XI–24 to XII–2–1935 (R. E. Turner); 1 male, 1 female, Dongarra, IX–26 to X–3–1935 (R. E. Turner); in British Museum, C. J. Drake, and J. A. Slater collections.



Text figure 2. *Onymocoris izzardi* n. sp., dorsal view.

This species differs from the congeners described above by virtue of its straminceous color, nearly straight lateral corial margin, hemelytra narrower than abdomen, and much more dense clothing of thick, white, recumbent hairs.

We take much pleasure in dedicating this interesting new species to Mr. R. J. Izzard, hemipterist, British Museum (Natural History).

Wechina, new genus

Body stout, depressed; juga convex, only slightly surpassing tylus, with midline distance beyond tylus less than one-half length of tylus; eyes strongly pedunculate; labium reaching to, or nearly to, posterior margin of prosternum; lateral margins of pronotum only moderately angulate at middle; antero-lateral angles bearing a short, stout outwardly-directed tubercle; abdomen and hemelytra very strongly and abruptly expanded laterally; male genital capsule opening to the left side.

Type species: *Wechina chinai*, new species.

Wechina chinai, new species

Rufous brown to largely rufescent with membrane fumose; legs testaceous, including tarsi; antennae testaceous, with fourth and sometimes apical two-thirds of third infuscate; dorsal surface sparsely covered with short, semi-erect, whitish pubescence. Head nearly flat, sloping downward anteriorly, with a median longitudinal groove on vertex; juga rather wide, cylindrical, moderately extended beyond tylus, their apices blunt and their inner margins just meeting before tylus, the latter nearly flat, a little depressed, cuneiform, with apex narrowly, acutely angulate; eyes shortly, stoutly pedunculate, curving obliquely backwards, with stalk feebly tilted upwards; length head .48–.52 mm., width across eyes .74–.82 mm., interocular space .45–.52 mm. Labium brownish with apex black, reaching to base of prosternum. Antennae slender, provided with short, pale pubescence, length antennal segments I, .12–.15 mm., II, .32–.38 mm., III, .32–.38 mm., IV, .30–.35 mm. Legs testaceous; tarsi pale; femora slightly swollen. Body beneath brownish, tinged with dull reddish, sometimes with sterna and a portion of venter black.

Pronotum moderately narrowed anteriorly, much wider across humeral angles, a little impressed on disc and between calli, feebly concave on posterior margin, coarsely, deeply, and rather closely punctate behind and between calli, also between calli and constricted collar; calli impunctate, not strongly elevated, smooth and a little darker than posterior part of pronotum; length of pronotum .42–.45 mm., width pronotum .80–.90 mm. Scutellum triangular, flat, rugosely punctate, length .30–.37 mm.; hemelytra not quite covering abdominal margins, clothed with short, inconspicuous, pale pubescence, corial margin distinctly convexly dilated beyond apex of scutellum, membrane lightly fumose, narrowly margined basally with dark fuscous adjacent to corial region, distance apex clavus-apex corium .70 mm., distance apex corium-apex abdomen .40 mm. Total length 2.48–2.72 mm.

Holotype (male): Lovedale, Nilgiri Hills, S. INDIA (T. V. Campbell); in British Museum (Natural History). *Allotype*: Naudidrug, S. INDIA (T. V. Campbell); in C. J. Drake Collection.

The small lateral tubercle on each antero-lateral pronotal angle will separate this insect immediately from all other members of the

subfamily. This is the only member of the Thaumastocorinae that has been taken thus far outside of the Australian region.

This genus and species are named in honor of Dr. W. E. China, distinguished hemipterist of the British Museum.

Baclozygum Bergroth 1909

Baclozygum Bergroth 1909: 332–333; Reuter 1912: 29–30; Barber 1920: 98 and 102; Kormilev 1955: 5.

Body flattened, head little deflexed; eyes only moderately pedunculate, anterior curvature of eyes meeting adjacent area of head in an even, continuous curve (Plate 1: 1), juga extending well beyond apex of tylus, not meeting at midline or only narrowly so, always longitudinally convex, never flattened or excavated above; labium very short, barely attaining anterior margin of prosternum; pronotum with very prominent antero-lateral angles, and with a sharply defined notch-like constriction at middle of lateral margin, producing a bilobed appearance; lateral margin of corium strongly and abruptly expanded caudad of apex of claval commissure; femora strongly incrassate; male genital capsule opening to the right side.

Type species: *Baclozygum depressum* Bergroth. Monobasic.

This well defined genus is known at present from only two species found in Tasmania and Australia.

KEY TO THE SPECIES OF BACLOZYGUM

1. Hind femora with numerous erect hairs, these as long as diameter of femur or nearly so; hemelytra with long erect hairs and (usually) conspicuous silky, semi-decumbent pubescence ..... **B. depressum** Bergroth

   Hind femora without long erect hairs, clothed only with very short decumbent pubescence, these hairs much shorter than diameter of femur; hemelytra with extremely short, sparse, decumbent hairs, thus appearing semiglabrous ..... **B. bergrothi** n. sp.

Baclozygum depressum Bergroth 1909

Baclozygum depressum Bergroth 1909: 333–334.

Color somewhat variable, grayish stramineous to reddish; anterior lobe of pronotum, scutellum, clavus, and apical part of corium often marked with blackish fuscous; head, front lobe of pronotum, and abdominal tergites sometimes reddish. Head sloping, much wider across eyes than its median length; eyes large, dark, strongly pedunculate (Plate 1: 1); length head .60 mm. (.53–.68), width across eyes .82 mm. (.75–.90), interocular space .52 mm. (.48–.55); antennae very long, finely pubescent, testaceous, last two segments usually blackish fuscous, lengths of antennal segments, I, .20 mm. (.18–.22), II, .52 mm. (.40–.60), III, .58 mm. (.48–.68), IV, .52 mm. (.42–.60); juga (Plate 1: 1) stout, considerably surpassing apex of tylus, subcylindrical, with dorsal surface longitudinally convex, sometimes more or less curved inward beyond tylus so that the sides are very slightly in contact; tylus stout, tapering apically; labium dark brown. Legs rather stout, stramineous, tarsi infuscate; femora moderately swollen, bearing short, sparse pubescence intermixed with long erect hairs. Anterior lobe of pronotum distinctly narrower than hind lobe (62: 84), punctate only in the narrow median impressed space between calli, collar not set off by punctures; hind lobe very coarsely punctate, truncate behind, both lobes subequal in length; length pronotum .55 mm. (.48–.60), width pronotum .87 mm. (.78–.98), length scutellum .32 mm. (.28–.38). Hemelytra provided with numerous fine, erect hairs; corial margin moderately, convexly widened beyond basal two-fifths; membrane lightly fumose, its basal margin narrowly infuscate adjacent to corium; distance apex of clavus to apex of corium .82 mm. (.70–.90), distance apex of corium to apex of abdomen .52 mm. (.50–.58). Total length 3.06 mm. (2.78–3.38).

Bergroth, in his original description of this species, mentioned more than one specimen. As he did not mention a type specimen, it is necessary to designate a lectotype for this species. The specimens Bergroth had before him are now in the British Museum, the male labeled "type" and the female "allotype." We here designate the male specimen from Hobart, Tasmania (J. J. Walker), B. M. 1913–315, as lectotype of *Baclozygum depressum* Bergroth. An appropriate label will be attached to the above designated specimen.

Material examined. In addition to the type material referred to above, we have seen 7 males and 13 females, from the following places. TASMANIA: Hobart, Huonville, Launceston, Bridport (A. M. Lea, J. W. Evans, J. J. Walker). WESTERN AUSTRALIA: Pemberton, Dongarra (P. Darlington, R. E. Turner). NEW SOUTH WALES: Murvillumbah, Sidney (F. Muir, J. J. Walker). QUEENSLAND: Toowong, Mt. Tambourine (F. A. Perkins, A. M. Lea). SOUTH AUSTRALIA: Murray Bridge (Lea). These specimens are in the British Museum, Museum of Comparative Zoology, R. L. Usinger, University of Queensland Museum, South Australian Museum, C. J. Drake, N. A. Kormilev, and J. A. Slater collections.

The systematics of this species are the most difficult of the entire family to understand. The series we have studied shows a considerable amount of variation, both in color and in structure. Most of the Tasmanian specimens have the juga much longer than the tylus, separated throughout, and widely flaring (Plate 1: 1) at the apices. The majority of specimens from the Australian mainland possess juga that are rounded rather than flaring at the apex, and in a few cases the juga meet on the midline before the tylus. The three specimens from eastern

Australia have the sides of the pronotum much less sharply angulate, possess more convergent juga, and are more heavily and densely pubescent on the hemelytra. Indeed, these specimens may well represent a distinct species. We prefer to await longer series in order to better evaluate the significance of these somewhat subtle differences. Tasmanian specimens tend to run darker with a considerable amount of dark brown color on pronotum and corium.

In addition to the characters mentioned in the key this species may usually be distinguished from *B. bergrothi* n. sp. by the presence of reddish or brownish coloration and by the juga not meeting anterior to the tylus.

Baclozygum bergrothi, new species

Testaceous with apical part of third and fourth antennal segments lightly brownish or fuscous, body beneath more brownish; membrane lightly fumose with border along corium narrowly infuscate. Vertex without evident median furrow; juga greatly exceeding apex of tylus, sharply longitudinally ridged or tectiform, curved strongly inward anteriorly so that their ends meet nearly face to face in front of midline of tylus; tylus tapering anteriorly, with dorsal surface nearly flat and slightly lower than that of juga; eyes stoutly stalked (as in Plate 2: 1), length head .51 mm., width head .72 mm., interocular space .42 mm. Antennae with short, inconspicuous pubescence; length antennal segments I, .15 mm., II, .38 mm., III, .48 mm., IV, .40 mm. Legs moderately stout with femora moderately incrassate, lacking long upright hairs, testaceous with tarsi scarcely darkened.

Pronotum depressed; anterior lobe somewhat narrower than hind lobe (48: 60), impunctate, broadly longitudinally impressed but without visible punctures between calli, slightly tumid on either side just behind collar, the latter short, constricted, not set off by punctures, calli nearly flat; hind lobe deeply and coarsely punctate, truncate on hind margin, length pronotum .48 mm., width pronotum .72 mm. Scutellum slightly infuscate, deeply punctate, length .30 mm. Hemelytra rather sparsely clothed with short, decumbent, whitish, pubescent hairs, the corial margin moderately convexly dilated beyond the basal two-fifths; membrane lightly fumose, narrowly margined opposite corial margin with fuscous as in *B. depressum*, distance apex clavus-apex corium .65 mm., distance apex corium-apex abdomen .38 mm. Total length 2.55 mm.

Holotype (male): Roebuck Bay, WESTERN AUSTRALIA, in British Museum (Natural History). *Allotype*: Pt. Lincoln, SOUTH AUSTRALIA (Lea), in South Australian Museum. *Paratypes*: 2 males, 2 females, Lindym, QUEENSLAND (W. R. Horne); Pt. Lincoln, Kangaroo Island, SOUTH AUSTRALIA (Lea); in University of Queensland Museum, South Australian Museum, C. J. Drake, and J. A. Slater collections. Included with the Pt. Lincoln material is a fifth instar nymph which, while somewhat shriveled, still reveals some interesting features.

Description of Nymph. Juga exceeding tylus, but not meeting mesad before it, eyes protuberant as in adults, pronotum narrowly explanate along lateral margins, dorsal surface impunctate, mesothoracic wing pads broad, flat, strongly divergent, extending caudad onto fourth abdominal tergite; dorsal scent gland openings present between tergites three and four, and four and five, with possibly a third opening between tergites five and six, right antenna oligomerous with three segments present.

The presence of at least two dorsal abdominal scent gland openings in the nymph is interesting, particularly since no scars were discernible in adults of the specimen of *T. hackeri* used for dissection during the study of the morphology.

B. bergrothi is readily separable from *B. depressum* by its short femoral pubescence and its nearly uniform pale coloration. In all the present specimens the juga meet on the midline anterior to the apex of the tylus. Several of the paratypes are somewhat larger than the described holotype.

This species is named in honor of the late master hemipterist Evald Bergroth.

Thaumastocoris Kirkaldy 1908

Thaumastocoris Kirkaldy 1908: Corrigenda and Plate 43; Bergroth 1909: 332; Reuter 1912: 29; Barber 1920: 98-99.

Thaumastotherium Kirkaldy 1908: 777-778; McAtee 1926: 14; Kormilev 1955: 5.

Strongly depressed species; head flattened, not at all deflexed, juga much enlarged, extended far beyond apex of tylus and broadly convergent, dorsally flattened or even excavated, never at all convex; eyes usually strongly pedunculate, anterior curvature of eyes meeting adjacent area of head at a sharp angle (Plate 1: 3); pronotum only moderately angulate on lateral margins; labium variable, but at most extending to base of prosternum; stridulatory sulcus present on prosternum; femora moderately to strongly incrassate; corium slightly to strongly expanded laterally; male genital capsule opening either to left or to right side.

Type species: *Thaumastocoris australicus* Kirkaldy 1908. Monobasic.

This genus is recorded thus far only from eastern Australia. As remarked below, the position of *T. petilus* n. sp. within the genus is somewhat questionable, but we prefer to take a conservative course and place it here pending the reception of additional material for study.

KEY TO THE SPECIES OF THAUMASTOCORIS

1 Labium relatively long, reaching or nearly reaching posterior margin of prosternum; lateral margin of corium distinctly convexly dilated opposite apex of claval commissure . . . . . **T. hackeri** n. sp.

Labium very short, scarcely attaining anterior part of prosternum; lateral margin of corium straight throughout, or at most very slightly expanded opposite apex of claval commissure 2

2. Juga very strongly convex on lateral margins (Plate 1: 6), excavated on dorsal surface; length of pronotum less than 1½ times maximum width across juga; male genital capsule opening to the left; eyes strongly pedunculate ..... **T. australicus** Kirkaldy

Juga nearly parallel-sided anteriorly (Plate 1: 5), never broadly expanded, their dorsal surface flat rather than excavated; length of pronotum nearly twice the maximum width across juga; male genital capsule opening to the right; eyes feebly subpedunculate ..... **T. petilus** n. sp.

Thaumastocoris australicus Kirkaldy 1908

Thaumastocoris australicus Kirkaldy 1908: Corrigenda and Plate 43; Barber 1920: 98.
Thaumastotherium australicum Kirkaldy 1908: 778; McAtee 1926: 14; Kormilev 1955: 5.

Moderately large, oblong, testaceous or ochraceous, scutellum slightly infuscate, apical part of third and fourth antennal segments blackish fuscous; tarsi mostly fuscous; eyes reddish fuscous. Head nearly flat, almost porrect, juga much exceeding tylus, flat, with dorsal surface widely, longitudinally scooped out, very broadly, convexly dilated on outer margin, with apices turned inward so that the ends meet face to face at midline in front of tylus (Plate 1: 6), greatest width across tylus three-fourths as wide as vertex (30: 40), length head .58 mm. (.55–.60), width across eyes .77 mm. (.70–.80), interocular space .48 mm. (.45–.50); antennae slender, clothed with pale pubescence, length I, .15 mm.; II, .33 mm. (.32–.35); III, .34 mm. (.32–.38); IV, .30 mm.; labium scarcely attaining anterior margin of prosternum, marked with blackish at apex.

Pronotum nearly flat, hind lobe distinctly wider than front lobe (64: 52) but scarcely longer; front lobe with collar and calli poorly differentiated, impunctate, calli very little raised, impunctate, impressed between; hind lobe truncate behind, provided with large, rather closely set punctures, length pronotum .46 mm. (.42–.50), width .78 mm. (.72–.82). Length scutellum .30 mm. Hemelytra with outer margin of corium only very slightly expanded laterally beyond the basal two-fifths, sparsely provided with very short, erect, seta-like, whitish pubescence; membrane slightly fumose, narrowly margined with fuscous along the corial border; distance apex clavus-apex corium .71 mm. (.65–.78), distance apex corium-apex abdomen .61 mm. (.55–.72). Total length 2.88 mm. (2.65–3.08).

The species is rather closely related to *T. hackeri* n. sp., from which it may readily be separated by the much more enlarged juga, shorter labium, less expanded corial margins and differently shaped paramere (Plate 2: 4). Specimens from South Australia have the juga somewhat less flaring.

Material examined (9 males, 15 females). QUEENSLAND: Sunnybank, Mt. Coot-tha, Brisbane, Carnarvon Range Upper Bullaroo Ck., Bunya Mt. (A. L. Turner, Koebele, Rosser, H. Hacker, T. E. Woodward). SOUTH AUSTRALIA: Bimbowrie, Ooldea, Kangaroo I., Barton (A. M. Lea). Specimens in C. J. Drake, University of Queensland, United States National Museum, South Australian Museum, British Museum, and J. A. Slater collections.

This species was originally described from a male specimen from Bundaberg, Queensland, collected by Koebele. The type specimen apparently was lost during the illustrating and has not been seen since that time. It is not now in the Kirkaldy collection at the Bishop Museum nor in the collection of the Hawaiian Sugar Planters Association, Honolulu, and thus was almost certainly destroyed. It seems highly desirable in this case to establish a neotype for the species in accordance with the provisions of the Copenhagen Decisions. We therefore designate as neotype of *Thaumastocoris australicus* Kirkaldy a male specimen from Queensland bearing the following labels. (1) "Mt. Coot-tha, 27–6–27, H. Hacker." (2) "Australia, H. Hacker." (3) "Neotype, *Thaumastocoris australicus* Kirk., C. J. Drake, J. A. Slater." This specimen is deposited in the United States National Museum. Notification of this action will be submitted to the Secretary of the International Commission upon publication of the present paper.

We believe this is the species that Kirkaldy had before him at the time he prepared the original descriptions of the species and subfamily. The specific description is very meagre but agrees in greater part with the species we have called *australicus*. The drawings of the type indicate an insect with slightly less dilated juga, with the lateral corial margin slightly more convexly rounded, and with the eyes slightly less pedunculate. The shape of the juga and the corial margin in the drawing are not significant as only slight artistic liberties would produce the result shown; the eyes are more serious, but again only a moderate artistic license would have produced the result indicated. On the other hand this is the only species that has juga at all of the type described and illustrated, the length of the labium (which is important in distinguishing species) is precisely as in Kirkaldy's figure, and the description of the eyes states that they are not quite contiguous with the pronotum—which almost certainly means that they are curved backward. The strongly punctured posterior pronotal lobe in this species is as described by Kirkaldy and is more pronounced than in any related species described by us. Also, of the plausible species only two have the lateral corial margin slightly broadened or straight, the others having a very convexly flaring expansion opposite the apex of the claval commissure. The color of this species also matches Kirkaldy's description, as does the length of the antennal segments.

Further circumstantial evidence to support the placing of this species as Kirkaldy's is the fact that the locality data are consistent. The Kirkaldy specimen was collected by Koebele during his biological control studies in eastern Australia and came from southern Queensland, the very area where the majority of our specimens of this species were taken. In addition, and also of considerable importance, is the fact that in the United States National Museum there is one thaumastocorid collected by Koebele which, although mutilated, belongs to this species.

We therefore conclude that we have correctly associated the Kirkaldy species with the present specimens and take this opportunity to designate the above specimen as neotype of *Thaumastocoris australicus* Kirkaldy.

Thaumastocoris hackeri, new species

Testaceous with scutellum lightly infuscate; membrane tinged with fumose, narrowly margined with fuscous adjacent to corial border. Head porrect, feebly tilted downward, wider across eyes than median longitudinal length, juga broad, much longer than tylus, with apices meeting at midline in front of tylus, scarcely widened anteriorly (Plate 1: 3), with outer margin distinctly raised so that dorsal surface slopes obliquely downward to mesal margin; tylus strongly tapering anteriorly, wedge-like; eyes strongly pedunculate, reddish fuscous, length head .59 mm. (.56–.62), width across eyes .86 mm. (.75–.90), interocular space .52 mm. (.45–.55); antennae testaceous with apical half of third and most of fourth segments dark fuscous, length antennal segments I, .20 mm., II, .48 mm. (.38–.52), III, .42 mm., IV, .36 mm. Labium brownish with apex dark fuscous, exceeding posterior margin of prosternum.

Pronotum depressed, front lobe distinctly narrower than hind lobe (74: 60); calli not clearly defined, slightly elevated; collar indistinct; front lobe sparsely coarsely punctate, hind lobe slightly longer than front lobe, closely coarsely and deeply punctate, length pronotum .52 mm. (.45–.55), width pronotum .88 mm. (.75–.92). Scutellum deeply punctate, a little wider at base than median length, length .32 mm. (.28–.35); hemelytra sparsely furnished with very short, upright seta-like, pale pubescence, with outer margin of corium strongly expanded beyond basal two-fifths; clavus broadened posteriorly, distance apex clavus-apex corium .83 mm. (.70–.90), distance apex corium-apex abdomen .60 mm. (.55–.68); legs moderately stout, with femora slightly incrassate. Total length 3.13 mm. (2.78–3.28).

Holotype (male): Bunya Mt., QUEENSLAND, Australia, III-1931 (H. Hacker), in C. J. Drake collection. *Allotype*: same data as holotype. *Paratypes*: 6 males, 6 females; QUEENSLAND: Bunya Mts., Blunder, S. Pine River, Kuranda, Mt. Gippe, Mt. Coot-tha, N. Pine River, Millwraith Range-Cape York (P. Darlington, H. Hacker, Koebele, A. L. Turner). NEW SOUTH WALES: Upper Williams River (Lea and Wilson). Paratypes in C. J. Drake, British Museum, J. C. Lutz, R. L. Usinger, Museum of Comparative Zoology, South Australian Museum, N. A. Kormilev, and J. A. Slater collections.

This interesting species is named in honor of the Australian hemipterist and collector who has collected such a considerable part of the present material.

Egg. Dark chocolate brown, elliptical and regular in outline; opercular cap present, heavily reticulated and with foveate pits, no evidence of projecting micropylar processes; surface of egg strongly and conspicuously reticulated in hexagonal or semi-hexagonal fashion; length .55 mm., maximum width .33 mm. (Plate 1: 9).

The egg described above, together with three others, was dissected from a female of the above species. Despite the fact that the eggs were still within the body cavity they obviously were fully developed. The very large size of the eggs for such a small insect is remarkable.

Thaumastocoris petilus, new species

Elongate, slender, subparallel-sided, stramineous with anterior part of pronotum and head somewhat brownish. Legs short, stout, with femora strongly incrassate (anterior femora strongly swollen on dorsal face), sparsely shortly pubescent. Head broad, with the fairly large swollen area on disc of vertex brownish, which is medially divided by a raised longitudinal sulcus, deeply longitudinally impressed on each side of raised discal area; juga wide, very long, gently dilated anteriorly, with dorsal surface flavous, flattened and feebly scooped out apically, lateral margins narrowly brownish, apices truncate, turned inward so that the broad ends meet mesad in front of tylus; tylus strongly tapering anteriorly, with dorsal surface longitudinally convex, cuneiform, with apex narrowly acutely angulate; eyes scarcely pedicellate, situated on side (at base) of the cephalic lobes of head (Plate 1: 5) length head .52–.58 mm., width across eyes .65 mm., interocular space .42 mm.; labium very stout, short, brownish, not attaining base of head. Antennae with first segment swollen, constricted at base, much shorter than juga, reaching to apex of tylus only, second segment slightly clavate. Length antennal segments I, .12 mm., II, .26 mm., segments III and IV missing.

Pronotum stramineous, more brownish in front, gently narrowed anteriorly, distinctly wider at base than back of collar (60: 50), collar constricted but poorly differentiated, calli raised, not ridged, with a few scattered punctures, posterior lobe of pronotum with humeral angles slightly raised, coarsely closely punctate, posterior margin slightly concave, length pronotum

.52 mm. width .70 mm.; scutellum blackish, with pits a little smaller than those on posterior portion of pronotum, length .29 mm.; hemelytra not covering all of lateral margins of abdomen, shorter than abdomen, testaceous, corial margin practically straight to apical fourth, then gently curving outward, membrane niveous, nearly opaque, margined with dark fuscous along corial border, distance apex clavus-apex corium .62–.68 mm., distance apex corium-apex abdomen .65 mm. Total length 2.82–3.02 mm.

Holotype (male): Kiata, VICTORIA, Australia, Oct. 1928 (F. E. Wilson); in C. J. Drake collection. *Allotype*: same data as holotype; in British Museum (Natural History).

This species, by virtue of its narrow form, inerassate legs, less strongly pedunculate eyes, and male genital capsule opening to the right side, is quite distinct from the other two members of the genus. We prefer to retain it in this genus at the present time despite some of these important differences.

Subfamily **Xylastodorinae** Barber 1920

Xylastodorinae Barber 1920: 103–104; Kormilev 1955: 7–8. *Discocorinae* Kormilev 1955: 7–8. NEW SYNONYMY.

Juga not exceeding tylus; eyes non-pedunculate; tarsal segments ellipsoidal, arolia and pseudarolia present; apex of tibiae lacking lobate sensory appendages; corium extended posteriorly along lateral margin of membrane to or almost to apex of wing; male genital parameres absent, genital capsule of male lacking a projecting process but with the capsule extended as a sheath around the slender tubular phallus.

Type genus: *Xylastodoris* Barber 1920.

Distribution: Cuba, U. S. A. (Florida), and Argentina.

Although we agree with Kormilev that his *Discocoris* is a very distinct form from *Xylastodoris luteolus* Barber we cannot feel that the differences are of such a nature or magnitude as to entitle the genus to subfamily status; besides, such a course would obscure the basic and most fundamental relationships within the family. It seems certain, at least to us, that two very well defined groups are represented in the family. In the western hemisphere occur the forms with arolia and pseudarolia, caudally extended corial margins, no genital parameres, lack of elongated juga, elliptical shape of tarsal segments and lack of sensory lobes from apex of tibiae. The forms in the eastern hemisphere differ from their new world relatives in all of the above features. Such characters as body shape, length of labium and open coxal cavities, while certainly fine taxonomic characters, do not appear to us to be of such a nature as to represent more than differences of generic level. We feel that Kormilev was more impressed by the differences mentioned above than by the resemblances, which is quite natural unless Australian material is at hand for comparison and study.

KEY TO THE GENERA OF XYLASTODORINAE

1. Labium very long, surpassing hind coxae; front coxal cavities open; body very ovate and strongly convex ..... **Discocoris** Kormilev
   Labium short, not nearly reaching middle coxae; front coxal cavities closed; body flattened, nearly parallel-sided and not at all ovate ..... **Xylastodoris** Barber

Xylastodoris Barber 1920

Xylastodoris Barber 1920: 100–101; Moznette 1921: 10–15; Blatchley 1926: 444; Costa Lima 1940: 124; Kormilev 1955: 6–7.

Body elongate, strongly depressed, weakly punctate; head straight, eyes weakly protruding, conspicuous, juga not surpassing tylus, subequal to it in length, ocelli widely separated, labium barely attaining anterior portion of prosternum; pronotum wider than long, lateral margins strongly explanate, collar undifferentiated; hemelytra subhyaline, lateral margin of corium explanate and slightly reflexed; fore coxal cavities closed; tarsi sub-globular; femora unarmed; male genital capsule very elongate, opening either to right or to left side.

Type species: *Xylastodoris luteolus* Barber 1920. Monobasic.

Xylastodoris luteolus Barber 1920

Xylastodoris luteolus Barber 1920: 101–102 and 105; Moznette 1921: 10–15; Blatchley 1926: 444–445; Costa Lima 1940: 124; Kormilev 1955: 6–7.

Strongly depressed dorso-ventrally, almost flat above, pale luteous with apex of labium and apical half of fourth antennal segment infuscate; juga almost attaining apex of tylus; eyes reddish or reddish brown, convergent anteriorly, exserted, non-pedunculate, length head .35 mm., width across eyes .46 mm., interocular space .33 mm. Antennae rather short, with third segment most slender, length antennal segments I, .10 mm., II, .16 mm., III, .18 mm., IV, .18 mm.; labium reaching slightly beyond anterior margin of prosternum.

Pronotum concavely arcuately narrowed anteriorly, widest across humeral angles, calli nearly flat, impunctate, posterior lobe sinuate behind, slightly longer than anterior lobe (the lobes not clearly differentiated in many specimens), shallowly punctate, length pronotum .35 mm. width pronotum .75 mm.; hemelytra distinctly wider and a little longer than abdomen, rather sparsely irregularly punctate, with outer corial margin considerably produced posteriorly so as to enclose part of the apical end of membrane, the latter very long, distance apex clavus-apex corium 1.00 mm. Total length 2.30 mm.

Material examined. Holotype, allotype, and many paratypes and additional specimens from Florida (U. S. A.) and Cuba.

In the original description Barber recorded the species from Cuba, where it was found feeding on the tender leaflets of the Royal Palm (*Oreodoxa regia* H. B. & K.). An excellent account of the habits and type of feeding injury has been published by Moznette (1921). According to this author serious injury is inflicted by the feeding of nymphs and adults on the developing leaflets while they are still wrapped up in the spike and to the folded leaflets as they slowly spread out. The extraction of the sap from the leaflets discolors the new growth and thus causes a set-back in the top growth of the palm trees.

Discocoris Kormilev 1955

Discocoris Kormilev 1955: 8–9.

Body broadly ovate, opaque, strongly convex above, strongly punctate; head slightly deflexed, eyes slightly subpedunculate, widely separated, moderately large; juga not surpassing and practically subequal in length to tylus, with dorsal surface flat or slightly excavated anteriorly, ocelli small, widely separated. Antennae short, slender, with basal segment not attaining apex of juga; antenniferous tubercles small, spinous, placed on front of face of outer shelf next to eyes; labium long, reaching to venter; mesosternum with long labial groove.

Pronotum very wide, transverse, wider than head across eyes, broadly deeply roundly excavated in front, with sides widely explanate. Scutellum fairly large, triangular; legs short, not very stout, femora slightly incrassate; hemelytra subglobate, wider than pronotum with sides broadly convexly expanded; clavus parallel-sided; male genital capsule usually (but not exclusively) opening to the left side.

Type species: *Discocoris vianai* Kormilev. Monobasic.

This newly described genus is quite distinct from *Xylastodoris* by the characters given in the key. As stated above, we do not consider this genus to represent a subfamily distinct from Xylastodorinae Barber.

Discocoris vianai Kormilev 1955

Discocoris vianai Kormilev 1955: 10.

Broadly ovate, brown, with explanate margins of pronotum slightly testaceous; eyes reddish; head convex above, sloping gently downward anteriorly; juga broad, nearly flat above, indistinctly scooped out apically, slightly convexly dilated beyond middle, with the outer convex margin of expanded part and apex jointly rounded, tylus not as wide as jugum, scarcely narrowed anteriorly, with dorsal surface feebly convex; antennae short, with short pubescence, segment one very short, slightly swollen, moniliform, not nearly attaining apex of jugum, two a little longer not quite as thick, also moniliform, three testaceous, most slender, four mostly blackish with somewhat longer pubescence than preceding; labium very long, extending onto basal part of abdominal venter.

Pronotum transverse, moderately convex above, wider at base than at apex (95: 65), widely convexly expanded between the base and apical angle, very broadly, deeply, concavely excavated in front, feebly sinuate behind, the calli not clearly differentiated, collar punctate, poorly defined and indistinct. Scutellum fairly large, wider at base than median length (50: 35). Hemelytra convex above, with lateral explanate margins slightly reflexed, widest opposite apex of scutellum, nearly overlapping and broadly rounded behind, membrane nearly twice as long as its greatest width, slightly tinted with fumose. Total length 2.50–2.70 mm.

Disposition of type: in Colección Nacional Argentina, Instituto Nacional de Investigación de las Ciencias Naturales, Buenos Aires, Argentina. The type series of nearly ninety specimens was taken on "palmito" (*Euterpe edulis* Mart.) at Piñalito, Departmento Frontera, Misiones, Argentina.

Material examined: 2 males, 2 females (paratypes).

ACKNOWLEDGMENTS

We should like here to extend our most sincere thanks to the following persons for valuable aid during the course of the present investigation: to Dr. Norman T. Davis of the University of Connecticut, who spent much time discussing and explaining details of morphology and relationship; to Dr. W. E. China of the British Museum (Natural History) for the loan of valuable material in his care and for generously allowing us to use drawings of the phallus and undersurface of *Baclozygum* that he had prepared several years ago; to Mr. P. D. Ashlock and to Mr. Henry Hurlbutt of the University of Connecticut for aid with details of nomenclature and for preparation of hind wings respectively; to Ing. Nicholas Kormilev of Argentina for great kindness in sending specimens of his *Discocoris* and for much valuable help and discussion by correspondence; to Dr. Reece I. Sailer of the United States National Museum for the loan of material and advice on nomenclature, to Dr. Linsley Gressitt of the Bishop Museum for aid in the attempt to locate the type specimen of *Thaumastocoris australicus*, and to Dr. G. F. Gross of the South Australian Museum, Dr. R. L. Usinger of the University of California, and Dr. T. E. Woodward of the University of Queensland for their kindness in arranging the loan of material from their respective institutions.

REFERENCES CITED

Barber, H. G. 1920. A new member of the family Thaumastocoridae. Bull. Brooklyn Ent. Soc. 15: 98–105.

Bergroth, E. 1909. Vier neue australische Hemipteren-Gattungen. Deutsche Ent. Zeitschr. 1909: 328–35.

China, W. E. 1933. A new family of Hemiptera-Heteroptera, with notes on the phylogeny of the suborder. Ann. Mag. Nat. Hist. (10) 12: 180–96.
1955. A reconsideration of the systematic position of the family Joppeicidae Reuter (Hemiptera: Heteroptera) with notes on the phylogeny of the suborder. Ann. Mag. Nat. Hist. (12) 8: 353–70.
China, W. E., and **N. C. E. Miller.** 1955. Checklist of family and subfamily names in Hemiptera-Heteroptera. Ann. Mag. Nat. Hist. (12) 8: 257–67.
China, W. E., and **J. G. Myers.** 1929. A reconsideration of the classification of the cimicoid families (Heteroptera), with the description of two new spider-web bugs. Ann. Mag. Nat. Hist. (10) 3: 97–125.
Costa Lima, A. da. 1940. Insetos do Brasil. II. Hemipteros. Rio de Janeiro: Escola National de Agronomia. 351 pages.
Dupuis, C. 1955. Génitalia des Hémiptères Hétéroptères. Mém. Mus. Nat. Hist. Nat., Paris, (A, Zool.) (n.s) 6(4): 183–278.
Gross, G. F. 1954. A revision of the flower bugs (Heteroptera, Anthocoridae) of the Australian and adjacent Pacific Regions. Part I. Rec. South Australian Mus. 11: 129–64.
Kirkaldy, G. W. 1908. Memoir on a few Heteropterous Hemiptera from eastern Australia. Proc. Linn. Soc. New South Wales, 1907, 32: 768–88.
Kormilev, N. A. 1955. Una curiosa familia de Hemipteros nueva para la fauna argentina, *Thaumastotheriidae* (Kirkaldy), 1907. Rev. Soc. Ent. Argentina 18: 5–10.
Leston, D., J. G. Pendergrast, and **T. R. E. Southwood.** 1954. Classification of the terrestrial Heteroptera (Geocorisae). Nature 174: 91–92.
McAtee, W. L. 1926. Notes on nearctic Hemiptera. Ent. News 37: 13–16.
Moznette, G. F. 1921. Notes on the royal palm bug. Quart. Bull. Florida State Plant Board 6: 10–15.
Poisson, R. 1951. Ordre des Hétéroptères (Heteroptera Latreille 1810—Frontirostres Fallén 1814). In: Traité de Zoologie, publié sous la direction de Pierre-P. Grassé, 10(2): 1657–1803, figs. 1463–1591.
Reuter, O. M. 1910. Neue Beiträge zur Phylogenie und Systematik der Miriden nebst einleitenden Bemerkungen über die Phylogenie der Heteropteren-Familien. Acta Soc. Sci. Fennicae 37(3): 1–171.
1912. Bemerkungen über mein neues Heteropteren-System. Öfv. Finska Vet. Soc. Förh. 54A(6): 1–62.
Usinger, R. L. 1943. A revised classification of the Reduvioidea with a new subfamily from South America. (Hemiptera). Ann. Ent. Soc. America 36: 602–18.

MATING, OVIPOSITION, AND DISCRIMINATION OF HOSTS BY APHIDIUS TESTACEIPES (CRESSON) AND PRAON AGUTI SMITH, PRIMARY PARASITES OF APHIDS[1]

P. S. SEKHAR

Sreevilas, Mavelikara, Travancore-Cochin, India

INTRODUCTION

The primary parasites *Aphidius testaceipes* (Cresson) and *Praon aguti* Smith (Braconidae, Aphidiinae) are endoparasites of various species of aphids, some of which are among the worst crop pests. *A. testaceipes* has been reported from Canada, the United States, Mexico, Bermuda, Puerto Rico, Brazil, Hawaii, and East Africa, and some of the aphids serving as its hosts are *Aphis gossypii* Glov., *Brevicoryne brassicae* (L.), *Macrosiphum granarium* (Kirby), *Myzus persicae* (Sulz.), and *Toxoptera graminum* (Rond.), according to Muesebeck *et al.* (1951) and Thompson *et al.* (1953). These authors report *P. aguti* as ranging in North America from Ontario to Virginia and west to Ohio, and list among its hosts *Macrosiphum pisi* Kltb., *M. rosae* (L.), and *M. solanifolii* (Ashm.).

Aphidius testaceipes has been reported on several occasions as one of the chief agents in checking pest outbreaks. One such instance was the control of the 1939 outbreak of the green bug, *Toxoptera graminum* (Rond.), in Oklahoma (Fenton and Fisher, 1940). Species of *Praon* (other than *P. aguti*, which was discovered comparatively recently) are also reported in many cases as potent enemies of aphids.

The taxonomic characteristics of the two primary parasite species have been treated in detail by Smith (1944).

In the study of a parasite species, knowledge of the influence of environment on the overall activity of the parasite has to be gained. Further, studies on the pattern of actions of the species during mating, oviposition and discrimination of hosts and the interrelationships of the three processes in particular need elaboration and analysis.

In the literature, specific contributions on the influence of environment and on mating and ovipositional acts have been met with in the cases of *A. testaceipes* and species of *Praon* other than *P. aguti*. From what has thus been described, it is noteworthy that many similarities exist between *A. testaceipes* and species of *Praon* referred to above.

Bilsing (1916), Janiszewska (1933), Spencer

[1]Part of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Massachusetts, Amherst, Mass., U. S. A.

Accepted for publication October 30, 1956.

(1926) and Sweetman (1936) gave some details on the influence of certain environmental factors on *A. testaceipes*. Wheeler (1923) and Spencer (1926) treated the mating acts of Aphidiinae in general. Webster and Phillips (1912) described and pictured the process of oviposition by *A. testaceipes*. Timberlake (1910) gave a very brief account of the process in *Praon simulans* Prov.

From the preceding account it is obvious that no contributions exist on the acts of mating and oviposition and discrimination of hosts by *P. aguti*. Hence, an original study was carried out to elucidate the nature of the three acts in *P. aguti*. In the case of *A. testaceipes*, notwithstanding the past contributions, it seemed necessary to make a more elaborate study of the three acts with a view to compare them with those of *P. aguti*. This paper is an attempt to realize the above aims.

MATERIALS AND METHODS

The Host Aphids. Various species of aphids belonging to different genera were obtained from both outdoors and indoors. Cultures of the following species were used for experiments.

1) *Aphis gossypii* Glov. (cotton aphis)
2) *Myzus persicae* (Sulz.) (green peach aphis)
3) *Macrosiphum rosae* (L.) (rose aphis)

The Parasites. The original specimens of *A. testaceipes* were secured from campus greenhouses of the University of Massachusetts while those of *P. aguti* were obtained from outdoor localities and later from the greenhouse of the Department of Entomology at the University. The parasites were identified by Mr. Muesebeck of the U. S. National Museum.

Rearing. The methods described by Smith (1944) were, in general, found satisfactory for rearing aphids and parasites. All hosts were kept under careful observation for at least ten days prior to the introduction of parasites. This was done to detect and eliminate any previously parasitized hosts as well as to bring the population of the hosts to a required level comprising all different stages.

For the convenience of using plants well adapted to confined greenhouse and laboratory conditions, the cotton aphis, originally collected from *Hibiscus* sp., was cultured on the alternate host, squash (*Cucurbita* sp.), while the peach aphis was cultured on radish (*Raphanus* sp.) in preference to tobacco (*Nicotiana tabacum*). The rose aphis was confined to rose itself throughout the observations.

The parasite *A. testaceipes* was cultured on *A. gossypii* and *M. persicae*, while *P. aguti* was cultured on *M. rosae*. The parasitized material was handled in the manner described by Smith (1944). The feeding method described by Holloway (1913) was found very satisfactory. However, when the parasites refused to feed on sugar solution, it was replaced by plant leaves covered with honey dew of the hosts, on which the parasites fed readily.

Experiments on mating were conducted in small vials. Because of the small size and the extreme mobility of the insects, only this technique was found suitable for observing the act carefully. The ovipositional strike studies were conducted by making use of battery jars and cheese cloth cages. The experimental temperatures varied from 25° to 35° C. and the relative humidities from 75 to 86 per cent.

MATING

First studies were aimed at determining the minimum time interval between emergence of the imagines and initial mating. Only individuals seen in the process of emergence were selected for this study. As soon as the specimens were dry and able to fly, a pair was continuously observed for two hours. Of 50 pairs of *P. aguti* thus studied, no mating occurred within the first hour and a half of observation, but more than 20% of the pairs mated within the next half hour. Of 50 pairs of *A. testaceipes* studied, no mating took place within the first hour and twenty minutes of observation, but within the next twenty-five minutes several matings were observed.

Further studies were conducted with the pairs which had not mated to determine whether or not a delay in the meeting of the opposite sexes would affect the consummation of mating. It was found that, of the 38 unmated pairs of the original 50 pairs of *P. aguti*, 30 mated readily when brought together again after an interval of about 22 hours since the first trial. The rest mated readily when again given the opportunity six hours later. In the case of *A. testaceipes*, all remaining unmated pairs of the original 50 mated, after repeated daily trials, within a maximum time interval of four days after emergence. Since all 50 pairs of *P. aguti* and *A. testaceipes* mated within 30 hours and four days respectively, it is obvious that the former species reaches sexual maturity within a day and a half and the latter within four days.

In general, the behavioristic patterns of mating of both species were similar. The female, prior to mating, remained motionless except for movements of the antennae and preening of the wings. As soon as the male approached her the pair touched antennae. Afterwards, the male began moving around the female, occasionally touching her with the antennae. In response the female moved away but the male followed until she was quiet. At this stage many instances were noticed in *A. testaceipes* where the male ran over his partner five or six times, at the same time vibrating his wings rapidly. When the male secured his position on the back of the female he crawled backward, still remaining on the female's back,

and bent the hind region of his abdomen downward to meet hers in copulation. This final act of copulation took an average of 52 seconds in *A. testaceipes*, confirming the observations of Wheeler (1923). The average time taken by *P. aguti* was 46 seconds. During this period the pair remained almost motionless. When the process was completed, the female remained quiet for some time after the male flew off. Occasionally more than one male was seen perched on the back of the mating pair. A female of either species was seen mating only once in her lifetime. Multiple matings seemed to be the rule with the male. Cases where males tried to mate with one another were also noticed. Such cases in *P. aguti* were observed often when one of the males had just finished a successful act of copulation. Temperature at or above 35° C. caused the parasites of both species to fly restlessly about and as a result no matings occurred. A decrease in temperature brought about an increase in the number of matings. The maximum number of matings observed for a single male of *A. testaceipes* during his lifetime was 19, all with different females. For *P. aguti* the maximum was 22.

It has been shown by other workers that there is a relation between the order of mating and the sex ratio of the progeny in species of parasites. These observations on multiple matings suggested similar investigations for the species studied here. Four cases of multiple matings were observed in detail for each species. In the case of *A. testaceipes*, four separate males performed 15, 19, 17 and 12 matings, respectively. Each male was given access to females in sequence. The pairs were isolated between times as continuous observations were not feasible. The results, in conformity with those of other workers for other species, showed that in early matings female offspring were preponderant and in the later ones the sex ratio of the progeny was approximately equal. The increase in the number of males from later matings may be correlated with a diminution of sperm supply in the aging male. It has been demonstrated by Whiting (1918) that virgin females of *A. testaceipes* occasionally produce a few females. However, in the present studies no females were obtained from such virgins. Observations with *P. aguti* gave the same results. Here, four males mated with 20, 11, 16 and 22 females, respectively. Since the sex ratio data for all four series of matings in each species showed remarkable similarity, it seems necessary to give only the averages (Table I).

TABLE I

THE RELATION OF ORDER OF MATING TO THE SEX RATIO OF THE PROGENY FROM FOUR MALES EACH OF *A. testaceipes* AND *P. aguti*

FEMALE NO.	AVERAGE NUMBER OF OFFSPRING PER FEMALE			
	A. testaceipes		*P. aguti*	
	Male	Female	Male	Female
1	33	71	9	52
2	26	91	13	60
3	20	81	13	57
4	25	66	18	52
5	25	46	24	51
6	43	61	14	24
7	21	27	16	25
8	30	32	19	31
9	43	44	31	24
10	88	86	39	48
11	94	77	29	43
12	93	81	30	48
13	104	97	30	34
14	36	29	31	43
15	34	28	44	35
16	67	63	25	18
17	60	57	32	29
18	20	19	33	37
19	19	21	37	33
20			58	55
21			36	38
22			26	30
Average per female	47 6	60 6	25 8	40 5
Total offspring	2999	3818	1781	2799

TABLE II

THE LOCATION OF OVIPOSITIONAL STRIKES ON HOST BODY BY *A. testaceipes* AND *P. aguti*
(200 cases observed for each)

POSITION OF STRIKES	*A. testaceipes*	*P. aguti*
Between cornicles	60	56
Sides of abdomen	49	45
Ventral abdomen	52	57
Thorax	10	12
Leg	10	2
Through leaf	2	10
Antennae	4	2
Head	13	16

OVIPOSITION

Most of the mated females of the previous experiment, as well as some unmated individuals, were closely observed for ovipositional behavior. These observations support those of Spencer (1926). In addition to the usual antennal tapping of the body of the hosts by both parasite species prior to striking with the ovipositor, females of *P. agouti* were occasionally seen pressing down the heads of the hosts with their fore legs. Generally, half-grown aphids were selected for attack. Ovipositional strikes were made on any part of the host's body but a decided preference was shown for the abdominal region (Table II).

If the hosts were numerous, the parasites often struck one host after another, but with fewer hosts the same aphid might be attacked more than once, the parasite depositing more than one

egg in the same host. However, the females of both parasite species generally avoided aphids that had already been successfully parasitized.

The maximum number of offspring developed from ovipositions by a single female of *A. testaceipes* was 254, while that of *P. aguti* was 230. The number of strikes often exceeded the above figures. Few progeny of either parasite species were obtained from thoracic strikes. Antennal and head ovipositional strikes yielded no progeny.

Initial ovipositions by mated females of *A. testaceipes* under laboratory conditions occurred 4 to 85 minutes after mating. For *P. aguti*, this interval was 2 to 70 minutes. Unmated females of the former laid eggs about two and a half hours after emergence, while those of the latter, about two hours after.

The total period of oviposition of *A. testaceipes* varied from two to ten days, while that of *P. aguti* ranged from approximately three to thirteen days when single females of the two species were allowed to oviposit for an hour per day (½ hour in the morning and in the evening). The average total number of strikes for the seven females of *A. testaceipes* was 101.8 strikes per day, the maximum number being accomplished on the third day (Table III). Seven females of *P. aguti* averaged 110.2 strikes, and the maximum activity was reached on the third to fifth day (Table IV).

During the progress of these observations there was some evidence of an increase of male progeny, especially from the collection of sessiles after the seventh day of oviposition. To clarify this, five mated females of *A. testaceipes* and five of *P. aguti* were liberated in separate cages containing their respective hosts, *Myzus persicae* and *Macrosiphum rosae*. The number of males and females that emerged from the sessiles collected from the fifth to twelfth day after exposure to the parasites showed that while female offspring were numerically greater in the early collections their number decreased more rapidly than that of the males. The average for parasites of each species is given in table V. Nevertheless, the total number of female progeny was always greater than that of the males for *A. testaceipes* studied. With *P. aguti*, the same trend was maintained on the whole, but No. 2 parasite produced slightly more males than females. The cause of this is unknown.

TABLE III

THE NUMBER OF OVIPOSITIONAL STRIKES OF FEMALES OF *A. testaceipes* WHEN ALLOWED FREE ACCESS TO HOSTS FOR ONE HOUR PER DAY ON SUCCESSIVE DAYS. (D = DEAD)

FEMALES	STRIKES ON SUCCESSIVE DAYS										TOTAL SINGLE STRIKES
	1	2	3	4	5	6	7	8	9	10	
1	10	36	42	30	0	7	4	0	0	D	129
2	14	32	41	20	9	4	1	1	D	0	122
3	9	40	42	19	7	0	D	0	0	0	117
4	6	14	32	10	5	1	1	1	0	D	70
5	15	20	29	19	6	6	3	1	1	D	100
6	10	31	33	D	0	0	0	0	0	0	74
7	16	29	31	12	5	3	3	1	1	D	101

Total number of strikes 713
Average number of strikes per parasite 101.8

TABLE IV

THE NUMBER OF OVIPOSITIONAL STRIKES OF FEMALES OF *P. aguti* WHEN ALLOWED FREE ACCESS TO HOSTS FOR ONE HOUR PER DAY ON SUCCESSIVE DAYS. (D = DEAD)

FEMALES	STRIKES ON SUCCESSIVE DAYS										TOTAL SINGLE STRIKES
	1	2	3	4	5	6	7	8	9	10	
1	7	12	0	35	31	D	0	0	0	0	85
2	7	15	35	29	29	11	5	0	2	D	133
3	5	10	32	48	32	9	0	D	0	0	136
4	6	14	30	29	30	10	3	0	D	0	122
5	7	16	27	29	28	7	0	0	0	D	114
6	9	11	25	20	22	5	4	3	D	0	99
7	3	11	22	21	20	0	0	5	1	D	83

Total number of strikes 772
Average number of strikes per parasite 110.2

DISCRIMINATION

It is undoubtedly true that a number of factors are involved in guiding the parasites to food and hosts. In this respect the power of discrimination plays a leading role. This role is verified in the case of *A. testaceipes* and *P. aguti* through the following experiments conducted on the nature of reactions of the mated females of the parasites while they alighted on host plants bearing many aphid hosts and their cast skins.

Five mated females of *A. testaceipes* were liberated successively into ten different glass cages enclosing the cotton aphis, *A. gossypii*, and their numerous cast skins (false hosts) under uniform conditions and their responses individually observed for 30 minutes in each cage. The same procedure was adopted for *P. aguti* with rose aphis, *M. rosae*, as hosts.

TABLE V

RELATIONSHIP OF THE SEQUENCE OF OVIPOSITION TO THE SEX OF PROGENY IN THE CASE OF *A. testaceipes* AND *P. aguti*

DAY OF COLLECTION	AVERAGE PER PARASITE					
	A. testaceipes			*P. aguti*		
	S	Os		S	Os	
		M	F		M	F
5	65	18 6	41 8	69 2	22 4	41
6	32 4	7 2	20 8	41 8	11 6	26 6
7	25	9 2	11 6	17 6	8	7 8
8	4	2 2	1 4	7 2	4	1 6
9	4	2 4	6	6 8	3 6	1
10	2 2	1 6	0	2 8	1 4	0
11	1 2	1	0	2	1 4	0
12	8	6	0	1 4	4	0

Total male offspring for five females of *A. testaceipes* 214
Total female offspring for five females of *A. testaceipes* 381
Total male offspring for five females of *P. aguti* 264
Total female offspring for five females of *P. aguti* 391

S —Sessiles
Os—Offspring
M —Male
F —Female

It was seen that as soon as a parasite alighted on a leaf surface bearing only the cast skins of the respective hosts, a series of searches were made over them with the antennae and in some instances with the fore legs. In some cases, the parasites even tried to assume the pose of oviposition once or twice. However, no eggs were deposited. Once the parasites had made a series of such encounters on the false hosts in the first few cages, they obviously became progressively less stimulated by the cast skins in the successive cages (Table VI). The total number of examinations made by a parasite, and thus the time consumed among false hosts was finally so much reduced that, in the last few cages, practically no time was spent in scrutinizing the false hosts. Since all the females of both species of parasites responded very similarly, only the average results are given.

From these observations two conclusions may be drawn. (1) As soon as a parasite, ready for ovipositional strikes, is given access to true and false hosts, only a small degree of stimulus (probably odor) is required to begin the process. Thus a parasite attacks cast skins in larger numbers in the first few cages. (2) As more and more eggs are deposited, the parasite seems to require a greater intensity of stimulus, which probably only the living true hosts can infuse. This may explain why it progressively ignores the cast skins. It may also be presumed that the frequent trials made by a parasite on cast skins by means of its ovipositor helps the parasite to differentiate the character of the particular host required, by way of chemical stimulation exercised through the sensory cells of the ovipositor.

TABLE VI

THE ABILITY OF *A. testaceipes* AND *P. aguti* TO DIFFERENTIATE BETWEEN FALSE HOSTS (APHID CAST SKINS) AND TRUE HOSTS (LIVING APHIDS) WHEN EXPOSED SUCCESSIVELY IN A SERIES OF SEPARATE CAGES

CAGE NO.	AVERAGE STRIKES PER PARASITE			
	A. testaceipes		*P. aguti*	
	False Hosts	True Hosts	False Hosts	True Hosts
1	22 6	3 6	20 4	1 2
2	19 2	10	19 2	9 6
3	9 4	15 6	10	13 2
4	6 4	19 6	5 2	16 6
5	1 4	18 6	1 6	24 6
6	1	24 6	8	20 4
7	8	22 8	2	27 4
8	2	22 6	6	26 2
9	0	18 6	2	22 2
10	0	13 8	0	19 8

SUMMARY

The primary parasites, *Aphidius testaceipes* (Cresson) and *Praon aguti* Smith, are endoparasites of various species of aphids. During the present study, the former was cultured in *Aphis gossypii* Glover and *Myzus persicae* (Sulzer) and the latter in *Macrosiphum rosae* (Linnaeus).

The earliest mating among newly emerged pairs of *A. testaceipes* occurred not less than one hour and twenty minutes after emergence. In the case of *P. aguti*, the same took place not less than one and one-half hours after emergence. When kept together two hours per day, all pairs of *A. testaceipes* had mated within a maximum time interval of four days after emergence and all pairs of *P. aguti* within a day and a half. Females were seen to mate only once in their

life. Multiple matings seemed to be the rule with males. A definite correlation between the order of mating and the sex of the progeny was observed in both parasite species. Mated females produced male and female offspring while unmated ones males only.

Fertilized females of *A. testaceipes* started oviposition in 4 to 85 minutes after mating, and *P. aguti* in 2 to 70 minutes. Unmated females of the former laid eggs about 2 hours and 30 minutes after emergence, whereas those of the latter began ovipositing about 2 hours after emergence. The process in both species took only fraction of a second. Half-grown and unparasitized aphids were usually chosen for attack. Preference was shown toward striking in the abdomen of the host species. When placed with hosts one hour per day, the maximum ovipositional activity of *A. testaceipes* was observed on the third day and that of *P. aguti* on the third to fifth day. The maximum number of offspring developed from ovipositions of a single female of *A. testaceipes* was 254 and from *P. aguti* 230. The sessiles from early ovipositions by a female produced more females than males, but the number of female progeny decreased more rapidly than the males as ovipositions advanced.

Both species of parasites discriminated between false hosts (cast skins) and true (living) hosts. This power of discrimination stimulated the parasites to ignore the false hosts progressively and in the end totally. Probably odor and frequent probing by the ovipositor supply the parasite species the necessary stimulus for discrimination.

ACKNOWLEDGMENTS

The author wishes to acknowledge with heartfelt thanks the cooperation and many helpful suggestions extended by Dr. Harvey L. Sweetman, the director, during the course of this study at the Department of Entomology, University of Massachusetts, Amherst, Mass. Sincerest gratitude for valuable guidance and encouragement during the study is also due to Doctors John F. Hanson, Department of Entomology; Jay R. Traver, Department of Zoology; Walter M. Banfield, Department of Botany; and Julius S. Greenstein, College of Veterinary Science, University of Massachusetts. The author also wishes to extend his appreciation to Dr. Charles P. Alexander, Head, and all other members of the staff of the Department of Entomology at the above university for their inspiring influences and interests in this study.

REFERENCES CITED

Bilsing, S. W. 1916. The green bug or spring grain aphis (*Toxoptera graminum* Rond.). Texas Agric. Expt. Sta. Bull. 13. 8 pp.

Fenton, F. A., and **E. H. Fisher.** 1940. The 1939 green bug outbreak in Oklahoma. Jour. Econ. Ent. 33: 631–3.

Holloway, T. E. 1913. Some methods of handling minute hymenopterous parasites. Jour. Econ. Ent. 6: 341–4.

Janiszewska, J. 1933. Untersuchungen uber die Hymenoptere *Aphidius* sp., Parasiten der Blattlaus *Hyalopterus arundinis* Fabr. Bull. Int. Acad., Cracow, B 2(7): 277–93. (Rev. Appl. Ent. (A) 21: 433.)

Muesebeck, C. F. W., *et al.* 1951. Hymenoptera of America north of Mexico. Synoptic catalog. U. S. Dept. Agric. Monograph 2: 91–92, 95–96.

Smith, C. F. 1944. The Aphidiinae of North America (Braconidae, Hymenoptera). Ohio State Univ. Contrib. Zool. Ent. 6. 154 pp.

Spencer, H. 1926. Biology of the parasites and hyperparasites of aphids. Ann. Ent. Soc. America 19(2): 119–51.

Sweetman, H. L. 1936. The biological control of insects. Ithaca, N. Y.: Comstock Publ. Co. 461 pp.

Thompson, W. R., *et al.* 1953. A catalog of the parasites and predators of insect pests. Hosts of Hymenoptera (Agaonidae to Braconidae). Commonwealth Inst. Biol. Control Publ., Sect. 2, Part 2. 190 pp.

Timberlake, P. H. 1910. Observations on the early stages of two Aphidiinae, parasites of aphids. Psyche 17(4): 125–30.

Webster, F. M., *et al.* 1912. The spring grain aphis or green bug. U. S. Dept. Agric. Bull. 110. 144 pp.

Wheeler, E. W. 1923. Some Braconids parasitic on aphids and their life history (Hym.). Ann. Ent. Soc. America 16(1): 1–29.

Whiting, P. W. 1918. Sex-determination and biology of a parasitic wasp, *Habrobracon brevicornis* Wesmae. Biol. Bull. 34(4): 250–6. (Rev. Appl. Ent. (A) 7: 297–8.)

FIFTH ANNUAL MEETING ENTOMOLOGICAL SOCIETY OF AMERICA

MEMPHIS, TENNESSEE, DECEMBER 2–5, 1957

Deadline for Receipt of Titles and Abstracts, Sept. 1, 1957.
Send to the Chairman of the Program Committee,

Dr. E. N. Woodbury,
Hercules Research Center,
Wilmington, Delaware

NANNOCYRTOPOGON (DIPTERA-ASILIDAE)[1]

J. WILCOX
Entomology Research Branch, Agr. Res. Serv., U.S.D.A.
AND
CHARLES H. MARTIN
Oregon State College

The genus *Nannocyrtopogon* was proposed by the writers (Wilcox and Martin, 1936) for eight species of small robber flies, two of which had previously been placed in the genus *Cyrtopogon* Loew. M. T. James (1942) has since described *aristatus* from Colorado. In the present paper the range is extended to Nevada and Arizona, but most of the species described are found in California.

Rather extensive collecting in southern California has revealed a number of new species and in addition the opposite sex of the three species described previously from a single sex. Additional material has been made available by A. L. Melander and P. H. Timberlake, University of California (Riverside), A. T. McClay, University of California (Davis), E. S. Ross, California Academy of Sciences, R. H. Beamer, University Kansas, P. H. Arnaud, Redwood City, California, Wm. A. McDonald, University of California (Los Angeles), and Larry W. Quate, University of Nebraska. A. Earl Pritchard, University of California (Berkeley), kindly sorted out material for us from the collection of the California Academy of Sciences (San Francisco). The types of the new species, unless indicated otherwise, will be deposited in this collection.

Nannocyrtopogon specimens have been taken only in the spring and summer, the greater number of species in May. Most of the species were found resting on the ground, on small rocks, sticks, or tin cans, and were easily collected. *N. timberlakei* was collected largely on living and dead trunks and logs of the Joshua tree, *neoculatus* on stacks of used lumber which was conveniently located in their habitat, and *lestomyiformis* and *howlandi* on outcrops of stone on the sides and tops of hills and mountains. Several species, such as *monrovia*, *oculatus*, *vandykei*, and *irvienei*, were difficult to capture. These species rested on the sides of twigs and branches about ½ inch in diameter underneath overhanging brush or chaparral.

A key for separating *Nannocyrtopogon* from related genera was given by the writers (Wilcox and Martin, 1936, 1957). In the present paper figures of the antennae of most of the species are given to facilitate their identification. Other useful characters for separating the species are found in the secondary sexual characters of the males. The tubercles on the frons may be small, round or pointed, pubescent and rather inconspicuous; in other species they extend from the facial gibbosity almost to the ocellar tubercle, are velvety black in the middle and margined with white pile which makes them very conspicuous. Further modifications take place in the form and vestiture of the frons, ocellar tubercle, and antennae. The fore tibiae and tarsi of the males also show considerable ornamentation in the amount, nature, and length of the hairs and bristles. The species fall into two groups, those with tubercles on the frons, and those without. *N. tolandi* has a suggestion of a tubercle on the frons opposite the antennae, but in this paper it is considered to be in the nontuberculate group.

In the males of the tuberculate group the face is strongly gibbous and in width is subequal to one eye, the mystax is composed of white and black bristles, the tubercles are usually ornamented, the frons and ocellar tubercle are modified and ornamented with tufts of white hairs, and the third antennal joint and style are modified or distorted. In the females of this group the face is broad but not strongly gibbous, the mystax is usually composed of sparse black bristles, the tubercles are not ornamented, the frons and ocellar tubercle are beset with black bristles and inconspicuous hairs, and the antennae usually show a more normal development with a style always present.

In the nontuberculate group the face is narrow, from one-half to four-fifths the width of one eye opposite the antennae, and is less gibbous in both sexes. In the males part of the face may be bare of pollen but in the female it is wholly pollinose. No great variation is seen between the sexes in the structure or ornamentation of the frons, ocellar tubercle or antennae. In most species the fore tibiae and tarsi of the males are ornamented with hairs or bristles or both which are not prominent or evident in the females.

KEY TO THE SPECIES (MALES)[2]

1. Frons to the sides of the antennae at least with a small tubercle 2
   Frons without tubercles 17
2. Wings infuscated 3
   Wings clear hyaline 8
3. Coxae and trochanters yellowish-red; femora black; tibiae and tarsi, brownish; upper two-thirds of

[1]Accepted for publication Nov. 5, 1956.

[2]Does not include *crumbi* n. sp., known only from a female specimen; see Key to the Species (Females).

mystax white; third antennal joint curved forward apically; length 7 mm. (Calif.) . . . . **j-beameri**

Legs black 4

4. Frons dull black; mystax black; male fore tibiae with a dense brush of brownish hairs dorsally; wings brown, anterior crossvein before middle of discal cell; length 5–6 mm. (Calif.) . . . . **minutus**

Frons pollinose 5

5. Face entirely pollinose; mystax black; male fore tibiae with erect white hairs dorsally; anterior crossvein at one-third length of the discal cell; length 4–5 mm. (Calif.) . . . . **monrovia**

Face largely bare of pollen at the middle 6

6. Apical third of the third antennal joint funnel shaped and twice as wide as basal part; mystax black with three white hairs on either side above; anterior crossvein at two-fifths length of the discal cell; length 6 mm. (Calif.) . . . . **antennatus**

Third antennal joint not enlarged apically 7

7. Face bare of pollen at middle; mystax black, white on the sides; male fore tibiae with short erect white hairs dorsally; anterior crossvein beyond middle of discal cell; length 7–8 mm. (Ariz.) . . . . **mingusi**

Face bare of pollen at middle but vertically bisected by pollinose line; mystax with mixed black and white hairs; male fore tibiae with sparse recumbent white hairs; anterior crossvein at or before middle of discal cell; length 5 mm. (Calif.) . . **stonei**

8. Tuft of hairs on male ocellar tubercle and frons, black; hairs on the first two antennal joints, black 9

Hairs mentioned above, white 10

9. Face white pollinose; frontal tubercles small, yellowish-white pilose; pollinose spots and bands on abdomen confined to segments 1 to 6; length 6.5–8 mm. (Calif.) . . . . **cerussatus**

Face of male largely subshining black; frontal tubercles triangular and extending half way to ocellar tubercle, velvety black, the outer margins yellowish pilose; pollinose spots wide and with the anterior bands extending to segment 7 of the abdomen; length 7 mm. (Calif.) . **richardsoni**

10. Anterior pollinose bands and posterior pollinose spots confluent at least on abdominal segments 2 to 4 11

Anterior bands and posterior spots on abdomen, widely separated 12

11. Mystax black, on the sides white; frontal tubercles rounded, white pilose; ocellar tubercle with long lateral tufts of white hairs; length 7–8 mm. (Calif.) . . . . **vanduzeei**

Mystax white with four black bristles above and a number on oral margin; frontal tubercles flat, appearing velvety black at some angles; frons and ocellar tubercle with a dense brush of erect white hairs; length 8–9 mm. (Calif.) . . **timberlakei**

12. Frontal tubercles of the male "eye-like" 13

Tubercles not "eye-like" 14

13. Antennae most slender at the basal third and widest at two-thirds its length; face largely white pollinose; without bristles below on the first two antennal joints; length 6–7 mm. (Calif.) . . **oculatus**

Third antennal joint most slender at three-fourths its length and noticeably enlarged apically, second joint with a strong black bristle below; face largely black; length 7 mm. (Calif.) . . . . **neoculatus**

14. Frontal tubercles broad, extending nearly to ocellar tubercle, velvety black, outer margins yellowish pilose; frons triangular, velvety black; hairs on ocellar tubercle part white and black; for tibiae with dense erect white hairs; length 8–9 mm. (Calif.) . . . . **irvinei**

Frontal tubercles small, white pilose; the frons white pollinose; sides of the face subshining black 15

15. Third antennal joint enlarged apically; style absent or shorter than the second antennal joint 16

Third antennal joint of uniform width, style subequal in length to the second joint; hypopleural fringe white with two or three black hairs above; male fore tibiae with recumbent white hairs dorsally and white bristles posteriorly; length 6–7 mm. (Calif.) . . . . **deserti**

16. Third antennal joint broadly expanded at apex and slightly cupped dorsally, no style visible; hypopleural fringe white; male fore tibiae and metatarsi with dense white appressed hairs dorsally; length 8 mm. (Calif.) . . . . **inyoi**

Third antennal joint rounded apically, short style evident; upper half of hypopleural fringe, black; male fore tibiae and metatarsi with sparse recumbent white hairs dorsally; length 7–8 mm. (Calif.) . . . . **howlandi**

17. Wings hyaline 18

Wings infuscated 20

18. Third antennal joint greatly enlarged at apex and with slender dorsal style; mystax black; upper half of male face shining, entirely pollinose in females; hypopleural hairs black above, white below; length 6–7 mm. (Colo.) . . . . **aristatus**

Third antennal joint normal 19

19. Face wholly pollinose, mystax black; male fore tibiae with sparse short white and black hairs dorsally; anterior crossvein at middle of discal cell; two scutellar bristles; length 6–7 mm. (Calif.) . . . . **tolandi**

Face narrowly shining black at the middle; mystax white on the sides, black at middle and below; male fore tibiae and tarsi with a brush of erect white hairs; anterior crossvein at two-fifths length of the discal cell; length 7–8 mm. (Calif.) . . . . **lestomyiformis**

20. Knob of the halteres red; face at the antennae three-fourths the width of one eye; male fore tibiae with dense recumbent black bristles dorsally and sparse ones posteriorly; length 7–8 mm. (Calif.) . . . . **sequoia**

Knob of the halteres brown 21

21. Area to the sides of the antennae, shining black . . 22

Frons pollinose 23

22. Anterior crossvein at middle of discal cell; mystax black; hairs on ocellar tubercle white; third antennal joint $1\frac{1}{3}$ times the length of the first two joints together; length 6–7 mm. (Calif.) . . . . **nitidus**

Anterior crossvein at five-eights the length of the discal cell; mystax black with white hairs intermixed; ocellar tubercle black haired; third antennal joint $1\frac{1}{2}$ times the length of the first two joints together; length 7–8 mm. (Calif.) . . . . **vandykei**

23. Mystax black 24

Mystax mixed black and white 25

24. Frons golden pollinose and haired; anterior tibiae and tarsi with dense short white hairs and with short black bristles; anterior pollinose fasciae on abdomen not reaching lateral margins of the segments; length 5–8 mm. (Idaho, Wash., Oreg., Calif.) . . . . **atripes**

Frons white pollinose and haired; anterior tibiae with numerous black bristles gradually becoming longer apically, tarsi with long black bristles; anterior pollinose fasciae reaching the lateral margins of the abdominal segments; length 9–10 mm. (Calif.) . . . . **nigricolor**

25. Posterior pollinose spots on abdomen not extending forward laterally; mystax black on oral margin plus about 12 scattered black ones above among the white ones; fore and middle tibiae and tarsi with rather dense short appressed white hairs, bristles black except those below on femora; length 8 mm. (Calif.) . . . . **bruneri**

Posterior pollinose spots on abdomen at least narrowly extending forward laterally to the anterior margins of the segments 26

26. Upper two-thirds of the mystax white; pollinose spots extending forward laterally to the anterior margins of the abdominal segments, otherwise broadly separated from the anterior fasciae; male fore and middle femora and tibiae with dense appressed white hairs and with three or four white bristles posteriorly on the tibiae; length 6–8 mm. (Calif.) ..... **arnaudi**

Upper half of the mystax white; posterior pollinose spots and the anterior fasciae broadly connected on abdominal segments 2 to 5; hairs of legs short white rather dense appressed, bristles black; length 9 mm. (Nevada) ..... **nevadensis**

KEY TO THE SPECIES (FEMALE)[3]

1. Frons to the sides of the antennae with a small tubercle; ocellar tubercle prominent and at least half the width of the frons at the vertex 2

Frons without tubercle to the side of the antennae; ocellar tubercle not prominent and not more than one-third the width of the frons at the vertex 15

2. Wings infuscated 3

Wings clear hyaline 7

3. Frons dull black; frontal and humeral hairs black; anterior crossvein at four-sevenths the length of the discal cell; length 5–6 mm. (Calif.) **minutus**

Frons pollinose 4

4. Anterior crossvein at or before the middle of the distal cell 5

Anterior crossvein beyond middle of discal cell 6

5. Hairs of the frons, black; anterior crossvein at one-third the length of the discal cell; length 4–5 mm. (Calif.) ..... **monrovia**

Hairs of the frons, white; anterior crossvein at the middle of the discal cell; length 5 mm. (Calif.) ..... **stonei**

6. Lateral posterior pollinose spots on the abdomen confined to the corners of the segments; anterior crossvein at five-eights the length of the discal cell; antennal and frontal hairs, black; length 7–8 mm. (Ariz.) ..... **mingusi**

Pollinose spots extending to anterior margins on the sides of abdominal segments 4 and 5; anterior crossvein at five-ninths length of discal cell; antennal and frontal hairs, white; length 7 mm. (Ariz.) ..... **crumbi**

7. Mystax with white hairs intermixed with the black 8

Mystax entirely black 13

8. Frons dull black 9

Frons pollinose 10

9. Antennae without strong bristles below; hairs on frons and ocellar tubercle, brownish or black; hypopleural hairs largely black; length 6–7 mm. (Calif.) ..... **oculatus**

First antennal joint with two and the second with one, black bristle below; hairs on frons and ocellar tubercle, white; hypopleural hairs largely, white; length 7 mm. (Calif.) ..... **neoculatus**

10. Anterior pollinose bands and posterior spots confluent or nearly so on abdominal segments 3 to 5 11

Abdominal pollinose bands and spots widely separated 12

11. Ocellar tubercle with short erect clumps of white hairs, along eye margin with sparse white and black hairs; antennae black haired, third joint slender and four times the length of the first two joints together; length 8–9 mm. (Calif.) ..... **timberlakei**

Ocellar tubercle with sparse white hairs, on the eye margins with small clumps of white hairs; antennae white haired, third joint twice the length of the first two joints together; length 7–8 mm. (Calif.) ..... **vanduzeei**

12. Third antennal joint bent forward on the apical third, style minute; hypopleural hairs, white; length 8 mm. (Calif.) ..... **inyoi**

Third antennal joint straight, style as wide as the apex of the third joint; upper fourth of the hypopleural hairs, black; length 6–7 mm. (Calif.) ..... **deserti**

13. Pollinose pattern on the abdomen extending to segment 6; ocellar tubercle and eye margins near vertex with tufts of black pile; length 7–8 mm. (Calif.) ..... **cerussatus**

Pollinose pattern on the abdomen extending to segment 5 14

14. Frons grayish pollinose, the hairs white; hairs on ocellar tubercle, white; length 7–8 mm. (Calif.) ..... **howlandi**

Frons dull black, hairs black; hairs on the ocellar tubercle, black; length 8–9 mm. (Calif.) ..... **irvinei**

15. Wings hyaline 16

Wings infuscated or with brown spots on the cross-veins and furcations 18

16. Third antennal joint greatly enlarged apically; style slender, minute; mystax, hairs and bristles of frons and ocellar tubercle, black; length 6–7 mm. (Colo.) ..... **aristatus**

Third antennal joint not enlarged apically 17

17. Mystax black, face wholly pollinose; length 6–7 mm. (Calif.) ..... **tolandi**

Mystax white on the sides, black in the middle and below; face narrowly shining black at the middle; length 7–8 mm. (Calif.) ..... **lestomyiformis**

18. Knob of the halteres, brown 19

Knob of the halteres, red 24

19. Small area to the sides of the antennae, shining black 20

Area to the sides of the antennae, pollinose 21

20. Style one-third the length of the coarctate third antennal joint; antennae black haired, the first joint with two or three black bristles below; length 6–7 mm. (Calif.) ..... **nitidus**

Style one-fourth the length of the slender third antennal joint; antennae white haired, the first two joints each with a black bristle below; length 7–8 mm. (Calif.) ..... **vandykei**

21. Mystax black; frons golden pollinose with black hairs and a few golden ones anteriorly; length 5–8 mm. (Idaho, Wash., Oreg., Calif.) ..... **atripes**

Mystax mixed black and white; frons gray or white pollinose 22

22. Upper half or more of the mystax, white; ocellar tubercle with white hairs and bristles; frons white pollinose; length 6–8 mm. (Calif.) ..... **arnaudi**

White hairs of mystax mixed with the black; ocellar tubercle with black bristles 23

23. Style one-third the length of the third antennal joint; frons white pollinose; humeral hairs white; length 9 mm. (Calif.) ..... **nevadensis**

Style half the length of the third antennal joint; frons gray pollinose; humeral hairs black; length 9–10 mm. (Calif.) ..... **nigricolor**

24. Hairs on the frons opposite the ocellar tubercle, black; style one-third the length of the third antennal joint; length 7–8 mm. (Calif.) ..... **sequoia**

Hairs on the frons, white; style half the length of the third antennal joint; length 9–10 mm. (Calif.) ..... **nigricolor**

[3]Does not include *j-beameri, richardsoni, bruneri,* or *antennatus* n. spp., known only from male specimens; see Key to the Species (Males).

Nannocyrtopogon antennatus, new species

Male: Length 6 mm. Head black; gray pollinose, large central part of face shining black.

Face at antennae three-fourths width of one eye; rounded tubercle on each side of antennae at eye margin gray pilose; ocellar tubercle three-fourths width of vertex and separated from lateral tubercles by a narrow furrow. Mystax black with about six long white hairs in upper part; occipital bristles black; ocellar tubercle and sides of frons with sparse crinkly, white hairs. Antennae (fig. 1) black; first two joints subequal in length, first with five long black bristles below and the second with one; hairs black, numerous on first joint; third joint 1½ times length of the first two together, slender on basal two-thirds, the apical third funnel shaped and obliquely cut off anteriorly, this surface slightly concave; style at apex, slender and about one-sixth length of third joint.

Mesonotum black, brown pollinose, the lateral and intermediate area, gray pollinose. Hairs and bristles black; two presutural, one supraalar, two postalar and four anterior dorsocentrals (the posterior ones are obliterated by the pin). Pleurae gray pollinose, hypopleural fringe black. Scutellum gray pollinose, four black marginal bristles.

Abdomen black; hairs on sides of first three segments white, three or four black bristles on sides of first segment, hairs otherwise short black. Sides of first segment, posterior corners of segments 2 to 5 and narrow anterior margins of 2 to 6, gray pollinose. Small genitalia black and black haired.

Legs black; coxae gray pollinose and white haired; bristles black; sparse hairs of middle tibiae white, otherwise brownish or black; fore tibiae with a rather dense fringe of recumbent hairs dorsally, whitish on apical half; claws black, brownish basally; pulvilli brownish and white; empodium brown.

Halteres dark brown; alulae and fringe white. Wings infuscated, veins dark brown, anterior crossvein at two-fifths length of the discal cell.

Holotype: Male, San Jacinto Mt. Trail, San Jacinto Mts., Calif., July 1 '52 (D. Shephard), University of California (Los Angeles).

Nannocyrtopogon arnaudi, new species

Male: Length 7 mm. Head black, white pollinose, hairs and bristles white except the lower third of the mystax and the occipital bristles, black. Face gibbous, evenly rounded in profile, four-fifths width of one eye at the antennae. Antennae (fig. 2) black, first two joints subequal in length and white haired, third joint coarctate and 1½ times the length of the first two joints together; style slender, half the length of the third joint.

Mesonotum black; brownish pollinose, the lateral margins, intermediate area and central stripe gray pollinose. Hairs white; bristles black, two presutural, one supra-alar, one postalar, and four or five weak posterior dorsocentrals. Pleurae grayish brown pollinose, upper two-thirds of hypopleural fringe black, lower third white. Scutellum grayish brown pollinose with four black marginal bristles.

Abdomen black, short white haired, longer on the sides of the first segment and laterally with three black bristles. Anterior margins of segments 2 to 6 and posterior corners extending forward narrowly along lateral margins on segments 1 to 7, gray pollinose. Genitalia black and black haired.

Legs black; coxae densely gray pollinose; hairs white, short, densely appressed dorsally on the fore and middle tibiae and tarsi; bristles black except three or four posteriorly on the fore and middle tibiae which are white; claws black; pulvilli brown.

Alulae brown, margin and fringe white. Halteres brown. Wings light brown, veins brown, anterior crossvein slightly beyond the middle of the discal cell, third vein branched beyond discal crossvein.

Female: Length 8 mm. Similar. Head grayish brown pollinose; four ocellar bristles and one strong and one weak bristle below on the second antennal joint, black. Six scutellar bristles. Anterior bands on abdomen confined to segments 2 to 5. Leg bristles black, hairs not dense or appressed on fore and middle tibiae and tarsi.

Holotype: male, Redwood City, San Mateo Co., Calif., June 2 '51 (Paul H. Arnaud, Jr.).

Allotype: female, same data.

Paratypes: Eight males and 1 female, same data; 1 male and 2 females, same data, April 27 '47 and May 13 '42; and 2 males, Woodside, San Mateo Co., Calif., May 17 '51 (Paul H. Arnaud, Jr.).

Named in honor of Paul H. Arnaud, Jr., who collected this species and also a number of other interesting Asilidae in California.

Nannocyrtopogon aristatus James

Nannocyrtopogon aristatus James, 1942, Jour. Kans. Ent. Soc. 15: 126.

Described from specimens of both sexes taken at Arboles, Colo., 6700′, May 17 '39 (B. Rotger, C. R.). We have not seen this species. The antennae are illustrated in the paper cited.

Nannocyrtopogon atripes Wilcox and Martin

Nannocyrtopogon atripes Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 39: 456–457.

Described from specimens collected in Idaho, Washington, Oregon and California. Additional specimens have been seen from California as follows: Fort Seward, Humboldt Co., June 21 '35 (E. W. Baker, T. Aitken) California Academy of Sciences. Pinecrest, Tuolumne Co., June 30 '47 and July 3 to 16 '48 (P. H. Arnaud, Jr.); Tahoe City, Placer Co., July 24 '43 (Arnaud); Tamarack Lake, Eldorado Co., August 10 '46 (Arnaud); and Castella Creek, Shasta Co., 4000′,

May 26 '51 (C. H. Martin). The antennae are illustrated in fig. 2.

Nannocyrtopogon bruneri, new species

Male: Length 8 mm. Head black, gray pollinose; face subshining, two-thirds the width of one eye at the antennae. Mystax composed of long dense black hairs on the oral margin and about 12 scattered black hairs on upper face with shorter more numerous white hairs intermixed; hairs on frons white, about 5 brownish ones on eye margins, ocellar tubercle with about 8 black hairs and some finer white ones; occipital bristles and hairs on upper occiput, black; beard white; hairs of palpi and proboscis, yellowish. Antennae (fig. 2) brownish black, first two joints subequal in length, white-haired, the second with one strong and one weak black bristle below and three or four short ones above; third brown, 1½ times length of first 2, above nearly straight, somewhat coarctate below; style acute, half length of third.

Mesonotum black; gray pollinose; intermediate spots and below humeri mesally, brownish. Hairs black, sparse and about as long as first antennal joint anteriorly. Bristles black, three presutural, two supraalar, three postalar, and three or four posterior dorsocentrals. Pleurae and coxae densely gray pollinose with a golden tinge, hairs white, upper two-thirds of hypopleural fringe black. Scutellum gray pollinose, seven strong black marginal bristles.

Abdomen black, sides of first and posterior corners of segments 2 to 6, rather broad anterior margin not reaching sides of 2 to 6, and segment 7 largely basally, gray pollinose. Hairs short, sparse, appressed white, longer and erect on sides of first three segments. Genitalia brown, sparse hairs white, comb of black bristles on either side.

Legs black, hairs white; bristles black; claws black, reddish basally; pulvilli white; empodia brown. Bristle-like hairs below on femora, yellowish white; fore and middle tibiae and tarsi with rather dense, short appressed white hairs.

Halteres brown; alulae brown, margin and fringe yellowish. Wings brown, veins brown, anterior crossvein at two-thirds the length of the discal cell, anal cell closed at wing margin.

Holotype: Male, Riverton, El Dorado Co. Calif., July 22 '16 (L. Bruner), in the University of Nebraska collection.

Paratype: Male, same data, lacks third antennal joint and style. In this specimen the anterior crossvein is at the middle of the discal cell and the anal cell is open.

Named in honor of the collector, one of the pioneer entomologists of the country.

Nannocyrtopogon cerussatus (Osten Sacken)

Cyrtopogon cerussatus Osten Sacken, 1877, West. Dipt., 308–309.
Cyrtopogon cerussatus Back, 1909, Trans. Amer. Ent. Soc. 35: 291–292.
Cyrtopogon cerussatus Melander, 1923, Psyche 30: 109.
Nannocyrtopogon cerussatus Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 29: 451.

We have seen no additional specimens of this species, described from Los Guilucos, Sonoma Co., Calif., type in Museum of Comparative Zoology. The female antennae are illustrated in fig. 1.

Nannocyrtopogon crumbi, new species

Female: Length 7 mm. Head black; densely white pollinose, face at antennae four-fifths the width of one eye, tubercles to sides of antennae gray pilose and about half the height of the first segment, ocellar tubercle two-thirds width of the vertex. Mystax, occipital and six bristles on ocellar tubercle, black; hairs white. First two antennal (fig. 1) joints brownish, white haired, the first longer than the second, the first with three or four and the second with one black bristle below; third joint slender, black, about twice the length of the first two together; style one-fourth length of the third joint.

Mesonotum black; brownish pollinose; laterally, anteriorly, the narrow central line and the suture, gray pollinose. Hairs short, on humeri white, otherwise black. Bristles black, two presutural, one supraalar, two postalar and six rather weak dorsocentrals. Pleurae densely gray pollinose, hairs white except one or two above in hypopleural fringe, brown. Scutellum gray pollinose; four strong and two weak black marginal bristles.

Abdomen black, hairs white, longer on sides of the first segment. Sides of first, narrow anterior margins not reaching sides and posterior corners of segments 2 to 5, gray pollinose, the posterior spots on segments 4 to 5 narrowly reach the anterior margins laterally.

Coxae densely white pollinose and white haired; legs otherwise brownish black with white hairs and black bristles; claws black, reddish at base; pulvilli brownish white; empodia black.

Halteres brown; alulae white with white fringe. Wings hyaline, veins dark brown, the anterior crossvein at five-eighths length of the discal cell.

Holotype: Female, Superior, Pinal Co., Ariz., April 1 '38 (S. E. Crumb).

Named in honor of the collector, our friend and former associate, S. E. Crumb.

Nannocyrtopogon deserti, new species

Male: Length 6 mm. Head black, densely gray pollinose except the face at the middle shining. Face swollen and eight-ninths the width of one eye at the antennae. Tubercles as high as the first antennal joint, rounded, occupying half the space between the antennae and eye margin, densely gray pollinose but appearing dull black at some angles. Lower third of mystax black, above white; ocellar tubercle with long tufts of white hairs on either side, frons opposite

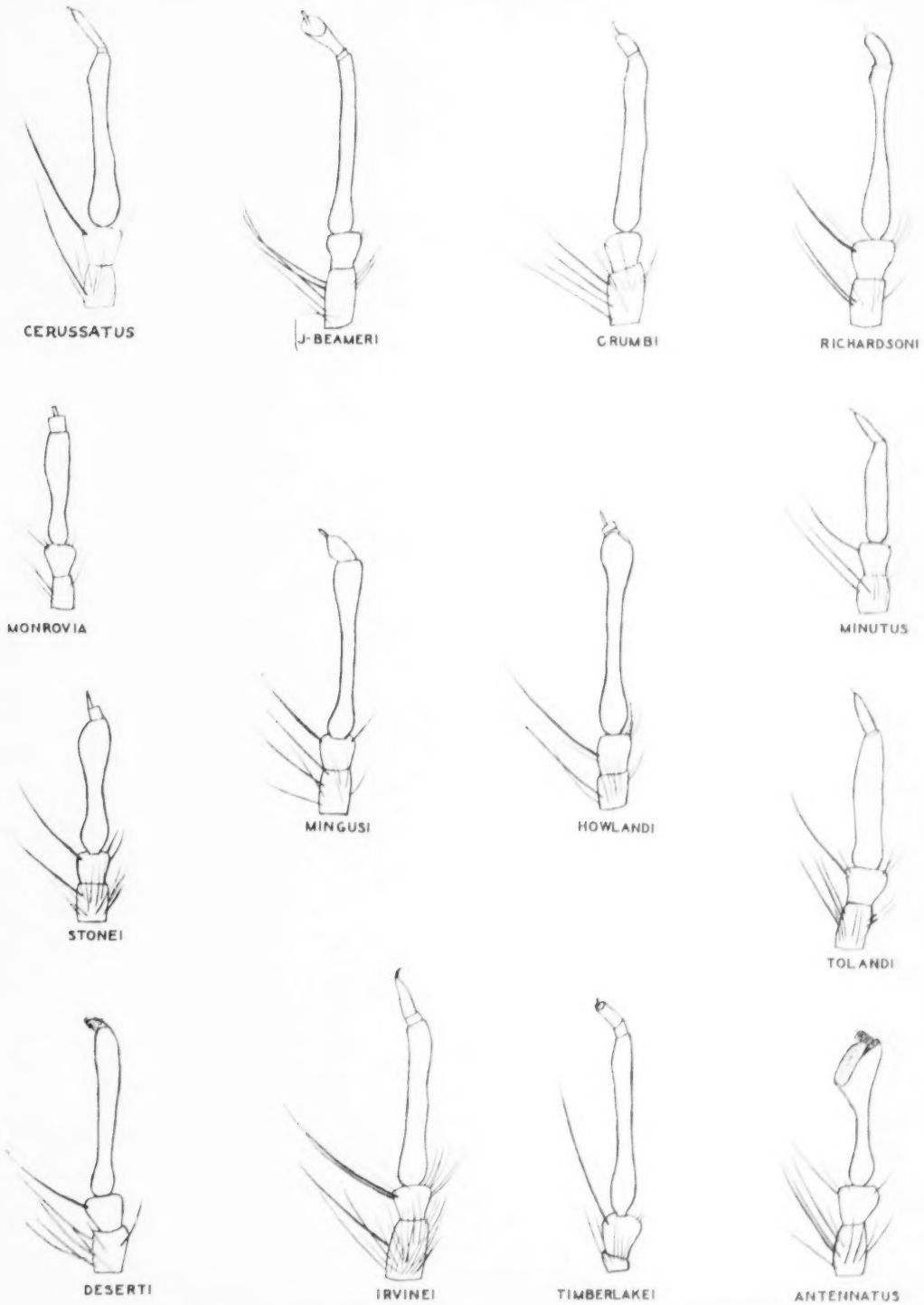


FIG. 1. Antennae of *Nannocyrtopogon* species, males except for *cerussatus* (Osten Sacken) and *crumbi* n. sp., which are female.

ocellar tubercle with thicker shorter tufts on eye margin; occipital bristles black; beard white. Antennae (fig. 1) black; first two joints subequal in length, white haired, the second with one weak black bristle below; third joint of uniform width and twice the length of the first two joints together; style about one-sixth the length of the third joint.

Mesonotum black; gray pollinose, the central stripe and intermediate spots brown. Sparse erect hairs white; bristles black, two presutural, two or three supra-alar, one postalar and about six dorsocentral, the anterior ones mostly white. Pleurae and coxae black, gray pollinose, hairs white. Scutellum black, gray pollinose, six strong black marginal bristles.

Abdomen shining black; sparse white haired, longer on sides of first two segments; posterior corners of segments 1 to 6 and narrow anterior margins of 2 to 6, gray pollinose. Genitalia black, white haired

Legs black; hairs white; bristles black, weak bristles below on femora and posteriorly on the fore and middle tibiae, white; claws black, reddish at base; pulvilli white; empodia black.

Halteres dark brown; alulae brown, margin and fringe white. Wings hyaline, veins dark brown, anterior crossvein at middle of discal cell, anal cell broadly open.

Female: Length 7 mm. Differs from male as follows: Head black, entirely gray pollinose, face not gibbous, mystax black, six black bristles on ocellar tubercle; first antennal joint with one strong and two weak black bristles below. Dorsocentral bristles all black; four scutellar bristles. Pollinose pattern on abdomen confined to segments 1 to 5, apical spines brown. Tibial bristles black.

Holotype: Male, Littlerock, Los Angeles Co., Calif., May 2, '48 (J. Wilcox).

Allotype: Female, same data, May 3, '41.

Paratypes: Thirty-two males, 18 females, same data as above (Guy F. Toland and J. Wilcox). One of the female specimens has a male head.

Nannocyrtopogon howlandi, new species

Male: Length 7 mm. Head black, gray pollinose, the face largely shining black, divided vertically by a pollinose line. Mystax below black, above white; frons with sparse erect hairs and a clump of curved hairs laterally opposite the ocellar tubercle, white; ocellar tubercle with a few white hairs anteriorly and five longer ones on each side; occipital bristles black; beard and hairs of palpi and proboscis white. Face strongly gibbous and at the antennae subequal to the width of one eye; frons with a small round, white pilose tubercle at each side of the antennae. Antennae (fig. 1) black, first two joints subequal in length, white haired and with two or three black bristles below on the first and one or two on the second; third joint slender at the middle and bulbous at each end, slightly more than twice the length of the first two joints together; style about one-seventh the length of the third joints, truncate apically with apical spine.

Mesonotum black, brown pollinose, the lateral margins, dorsocentral stripes and the central stripe, grayish pollinose. Hairs white; bristles black, three presutural, two supra-alar, one postalar and six or seven weaker dorsocentral. Pleurae grayish golden pollinose, hairs white, upper two-thirds of hypopleural fringe black. Scutellum grayish pollinose with eight strong black marginal bristles.

Abdomen black, sides of the first segment, anterior margins of segments 2 to 7 and posterior corners of segments 2 to 6, gray pollinose, spots of segments 5 to 6 reaching the anterior margin laterally. Hairs white, longer on the sides of the first two segments. Genitalia black, white-haired.

Legs black, coxae gray pollinose and white haired; hairs white; bristles black; claws black, reddish at base; pulvilli white; empodia black. Hairs on fore and middle tibiae and fore tarsi, appressed and quite dense.

Halteres brown; alulae brown, margin and fringe yellowish; wings hyaline, veins dark brown, the anterior crossvein at five-ninths the length of the discal cell.

Female: Length 8 mm. Face and front grayish pollinose and the face at the antennae five-sixths the width of one eye; mystax largely black. Tubercles smaller and pollinose; ocellar tubercle with eight strong erect black bristles. Third antennal joint not as slender at the middle but definitely larger at each end, first joint with one weak black bristle below. Seven scutellar bristles. Pollinose pattern on abdomen confined to segments 1 to 5. Fore and middle tibiae without dense appressed white hairs.

Holotype: Male, The Gavilan, Riverside Co., Calif., May 23, '48 (J. Wilcox).

Allotype: Female, same data.

Paratypes: Forty-six males and 40 females, same data (A. F. Howland and J. Wilcox), May 6 '48 and May 21 '41; and 3 males and 3 females, Yucaipa, Calif., June 11 '45 (Howland and Wilcox). Two males, Gilman Hot Springs, Riverside Co., Calif., May 30 '41 (E. C. Van Dyke) in the California Academy of Sciences. Four males and 1 female, Beverly Glen, Santa Monica Mts., Los Angeles Co., Calif., May 17 '52; Westwood Hills, Los Angeles Co., Calif., May 29 '49; Beverly Glen, Los Angeles Co., Calif. 520616X; Pasadena, Calif., June '44 (K. Cooper); Aguanga, Calif., 4 mi. W., Riverside Co., April 24 '51 (R. E. Berchell); and Big

EXPLANATION OF FIGURE 2

FIG. 2. Antennae of *Nannocyrtopogon* species, male except for *inyoi* n. sp., where those of female are shown on the right and of the male on the left.

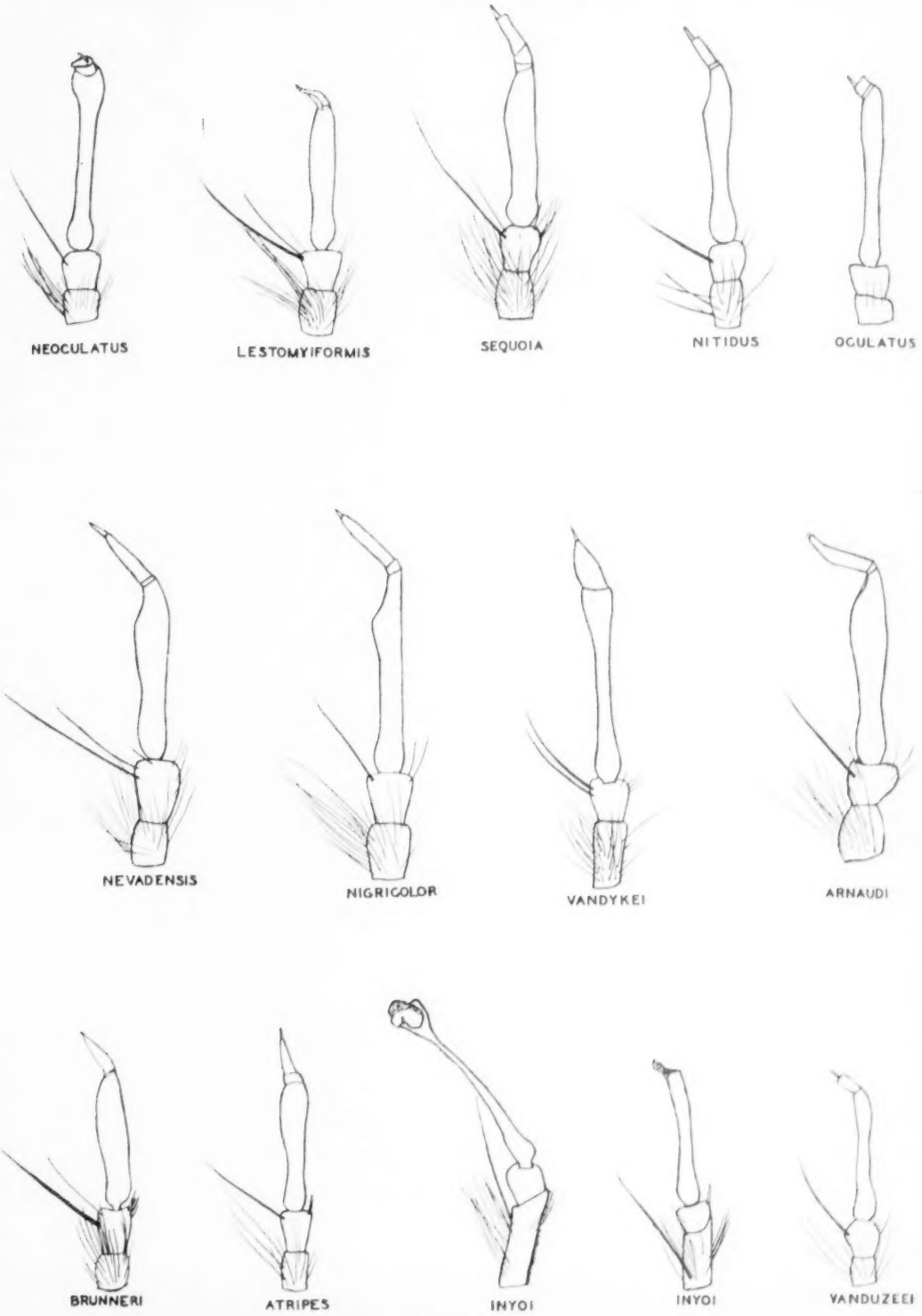

NEOCULATUS
LESTOMYIFORMIS
SEQUOIA
NITIDUS
OCULATUS
NEVADENSIS
NIGRICOLOR
VANDYKEI
ARNAUDI
BRUNNERI
ATRIPES
INYOI
INYOI
VANDUZEEI

Figure 2

Dalton Cn., Los Angeles Co., Calif., July 20 '52; University of California (Los Angeles). Eight males and 1 female, Riverside, Calif., May 7 and 9 '35 and April 20 '37 (P. H. Timberlake) and 2 males, 1½ mi. W. of Perris, Calif., April 27 '38 (Timberlake), University of California (Riverside). One male, Perris, Calif., May 10 '45 (A. L. Melander), in the Melander collection. Three males and 2 females, Tanbark Flat, Los Angeles Co., Calif., July 8 and 12 '52 (R. E. Wagner and D. Shepard), University of California (Davis).

Named in honor of Adelbert F. Howland, who helped to collect this and many other interesting Asilidae in southern California.

Nannocyrtopogon inyoi, new species

Male: Length 8 mm. Head black; face and front yellowish gray pollinose, sides of face bare of pollen, occiput gray pollinose. Face strongly gibbous, at the antennae subequal to the width of one eye, mystax white with two pair of black hairs on the oral margin and a long pair at the middle of the gibbosity. Tubercles rounded, yellowish pilose, in diameter about equal to the length of the first antennal joint, frons deeply grooved laterally and with four or five short white hairs opposite ocellar tubercle; ocellar tubercle rounded with four or five long white hairs on each side and a few shorter ones at the middle anteriorly; occipital bristles black, beard white. Antennae (fig. 2) black; first joint 1¼ times the length of the second, white haired and with one to three weak black bristles below; second short white-haired; third twice the length of the first two together, slender, tapering to the apical fourth which is broadly expanded and slightly cupped apically; no style evident.

Mesonotum black, silvery gray pollinose, the central stripe and intermediate area light brown; hairs white; bristles black, two or three presutural, one or two supra-alar, two postalar and seven dorsocentral. Pleurae gray pollinose and white haired, hypopleural fringe white. Scutellum gray pollinose, six strong black marginal bristles.

Abdomen black; short sparse hairs white, longer on sides of first three segments; sides of first segment, posterior corners of segments 2 to 7 and anterior margins of segments 2 to 7 gray pollinose, spots and bands confluent on segments 6 and 7 and nearly so on segment 5. Genitalia dark brown, hairs white.

Legs black; bristles black; hairs white, fore tibiae and tarsi with dense appressed white hairs dorsally; claws and empodia black, pulvilli brown.

Alulae brown, margin and fringe yellowish; halteres brown. Wings hyaline, veins brown, anterior crossvein at middle of discal cell, third vein branched beyond discal crossvein.

Female: Length 8 mm. Differing as follows from male. Face rounded but not gibbous, grayish pollinose, mystax composed of 12 to 14 black bristles with shorter white hairs intermixed; tubercles somewhat smaller and frons without deep lateral grooves; ocellar tubercle about half width of frons at vertex (in male two-thirds width) with two long and one or two shorter black bristles and some fine white hairs. First two antennal joints as in male, third joint of uniform width, slightly larger at base and apex and at the apical two-thirds bent forward at a slight angle; style minute about half the length of the second joint. Pollinose markings on abdomen confined to segments 1 to 5. Fore tibiae and tarsi white-haired, but hairs finer and less dense.

Holotype: Male, Independence, Inyo Co., Calif., May 18 '56 (J. Wilcox).

Allotype: Female, same data (Itol J. Wilcox).

Paratypes: Eighty-eight males and 96 females, same data and collectors; 2 males and 3 females, Olancha, Inyo Co., Calif., May 18 '56 (Wilcox); male and female, Lone Pine, Inyo Co., Calif., June 10 '49 (Wilcox). One female, Lone Pine, Inyo Co., Calif., May 31 '37 (E. C. Van Dyke), in the California Academy of Sciences.

Nannocyrtopogon irvinei, new species

Male: Length 8 mm. Head black; face gray pollinose, subshining black above; frons and ocellar tubercle velvety black, lateral margins of the frons yellowish white pollinose; occiput gray pollinose. Mystax black, a very few fine white hairs intermixed; frons opposite ocellar tubercle with a short tuft of black hairs and a similar tuft of white hairs; ocellar tubercle with about 24 erect black hairs; occipital bristles black; beard and hairs of palpi and probosis white. Face strongly gibbous, at the antennae 1⅕ times the width of one eye; tubercle extending from below the antennae to the ocellar tubercle at a slight angle, margined with short yellowish pile, velvety black internally; ocellar tubercle about half the width of the frons at vertex, frons parallel-sided and slightly wider than face at antennae. Antennae (fig. 1) black, first joint slightly longer than second, both short white haired, the first with one or two and the second with two black bristles below; third joint 1¾ times the length of the first two joints together, slender and slightly coarctate; style one-third the length of the third joint, abruptly pointed apically and with apical spine.

Mesonotum gray pollinose, the central and intermediate stripes bisected by the transverse suture, brown; hairs white; bristles black, two presutural, two supra-alar, two postalar, and eight dorsocentral. Pleurae grayish pollinose with a golden tinge, hairs white including the hypopleural fringe. Scutellum gray pollinose with six black marginal bristles.

Abdomen black, sides of first segment, anterior margins and posterior corners gray pollinose, the posterior spots becoming larger apically so that

they reach the anterior margins on segments 5 and 6, segment 7 pollinose basally. Hairs white, longer on sides of first two segments. Small genitalia brown, white haired.

Legs black; coxae gray pollinose and white haired; hairs white; bristles black except a double row posteriorly on the fore tibiae, white; claws black, reddish basally; pulvilli white; empodia black. Fore femora, tibiae and tarsal segments 1 to 3 with longer dense white hairs, on the tibiae the hairs are about as long as the diameter of the segment and form an erect fringe dorsally, anteriorly and posteriorly.

Halteres brownish black; alulae brownish with a yellowish margin and fringe. Wings hyaline, veins dark brown, anterior crossvein at five-ninths the length of the discal cell.

Female: Length 9 mm. Similar to male. Face not as gibbous, subequal in width to one eye at the antennae; frontal tubercles smaller but of similar structure without pilose margin. Sides of first segment, anterior margins and posterior corners of abdominal segments 2 to 5 pollinose and not connected on any segments. Fore legs with short, sparse, appressed white hairs.

Holotype: Male, The Gavilan, Riverside Co., Calif., May 21 '41 (J. Wilcox).

Allotype: Female, same data.

Paratypes: One male, same data (M. I. Irvine); 4 females, same locality May 23 '48 (Guy F. Toland and J. Wilcox); 14 males and 14 females, Pinyon Flat, Riverside Co., Calif., May 10 and 11 '53 (C. H. and Dorothy Martin and J. Wilcox); 1 male, Dripping Springs, Riverside Co., Calif., May 11, '53 (J. Wilcox). One male, Crystal Lake, 4700′, Los Angeles Co., Calif., July 9 '52 (S. Miyagawa); 2 males and 5 females, Tanbark Flat, Los Angeles Co., Calif., June 22 '50, June 29, July 7 and 20 '52 (A. T. McClay, Wm. McDonald and K. G. Whitesell), University of California (Davis), and 3 males and 3 females, Tanbark Flat, Los Angeles Co., Calif., July 8 to 20 '52 (D. Shepherd and R. E. Wagner), University of California (Los Angeles).

Named in honor of Milton I. Irvine, who helped to collect the original series of this species.

Nannocyrtopogon j-beameri, new species

Male: Length 7 mm. Head black, margins of the face and frons densely, the central areas and ocellar tubercle thinly, grayish white pollinose; the occiput gray pollinose. Hairs on the oral margin black, long sparse hairs on upper face white; frons with curved white hairs laterally opposite ocellar tubercle; ocellar tubercle with about 20 long, erect, white hairs; occipital bristles black; beard and hairs of palpi and proboscis, white. Face at the antennae four-fifths the width of one eye; frons with a very small tubercle opposite the antennae and above with five vertical grooves; ocellar tubercle about half the width of the frons at the vertex. First two antennal (fig. 1) joints brownish, the first $1\frac{1}{2}$ times the length of the second and with one to three black hairs below, first two joints with sparse short black hairs; third joint black, slender, of nearly uniform width and $1\frac{1}{2}$ times the length of the first two joints together; style black, one-third the length of the third joint, the first joint very short and narrow, the second fluted apically and obliquely truncate with a depression from which the spine arises.

Mesonotum black, the lateral margins and narrow dorsocentral stripes, gray pollinose, the intermediate areas, golden pollinose. Hairs and bristles, black, the hairs on humeri white, two or three presutural, one or two supra-alar, one postalar, and five dorsocentral. Pleurae grayish golden pollinose, the ground color black except the metapleurae which appear reddish, hypopleural hairs black, the lower third yellowish. Scutellum gray pollinose with seven strong black marginal bristles.

Abdomen black, sides of the first segment, anterior margins of segments 2 to 7 and posterior corners of 2 to 6, gray pollinose, on segment 6 the anterior band and posterior spots are confluent. Hairs short, white, longer on the sides of the first two segments, first segment with three or four black bristles on each side. Genitalia small, brown, gray pollinose basally and white haired.

Coxae and trochanters yellowish red, the coxae gray pollinose and white haired. Femora black, the narrow base yellowish red, tibiae and tarsi brownish, claws black, the base reddish, pulvilli brown, empodia yellowish red. Hairs white and bristles black. Fore tibiae and metatarsi heavily beset dorsally with short, white, recumbent, scale like hairs.

Halteres brownish black, alulae brown, margin and fringe yellowish. Wings lightly and evenly infuscated, veins brown, anterior crossvein at four-sevenths the length of the discal cell.

Holotype: Male, Sargent, San Benito Co., Calif., July 22 '35 (Jack Beamer), in the Snow Collection, University of Kansas.

Named in honor of the collector, who has collected many fine species on his father's expeditions.

Nannocyrtopogon lestomyiformis
Wilcox and Martin

Nannocyrtopogon lestomyiformis Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 29: 454–455.

Female: Length 8 mm. Similar to the male except for sexual differences. Mystax black with a few shorter fine white hairs above on either side, grayish pollinose the central stripe black and shining, two-thirds the width of one eye at the antennae. Frons grayish pollinose, hairs white; ocellar tubercle with six erect black bristle-like hairs and some shorter fine white hairs. First antennal (fig. 2) joint with one or two black bristles below, slenderer than the one below on

the second joint. More brown pollen on disc of mesonotum; seven scutellar bristles. Pollinose pattern of abdomen confined to segments 1 to 5; apical spines brownish black. Fore tibiae and metatarsi with short sparse recumbent white hairs dorsally, the fore tibiae with a row of black bristles in length about equal to the diameter of the segments. Anterior crossvein at three-fifths the length of the discal cell, anal cell closed at wing margin.

Neallotype: female, Oak Grove, San Diego Co., Calif., May 9 '45 (A. L. Melander), in Dr. Melander's collection.

A male, same data, agrees almost perfectly with the description of the holotype. We are especially pleased to see these specimens from a definite locality in San Diego Co., Calif., as the type locality "San Diego County, Desert Edge" could be any place within 1000 square miles.

Other specimens, both sexes, taken at Pinyon Flat, Riverside Co., Calif., May 10 '53 and May 26 '48 (Guy F. Toland, A. F. Howland and J. Wilcox); Oak Grove, San Diego Co., Calif., April 20 '52 (C. H. and D. Martin); Aguanga, Riverside Co., Calif., May 11 '53 (Wilcox); Banning, Calif., May 14 '53 (Wilcox); and 2 females Andreas Canyon, Riverside Co., Calif., April 21 '51 (R. C. Bechtel), University of California (Davis).

Nannocyrtopogon mingusi, new species

Male: Length 7 mm. Head black; densely gray pollinose, the central portion of the face shining. Face strongly gibbous reaching to antennae and at the antennae seven-tenths the width of one eye; tubercles small and half the height of the first antennal joint, apex black. Mystax black and white mixed; short lateral hairs on frons and sparse long tufts on ocellar tubercle, white; occipital bristles black, short sparse hairs white. Antennae (fig. 1) black; first two joints subequal in length, black haired, the first with two black bristles below and the second with one; third joint twice the length of the first two joints, of nearly uniform width but slightly wider at base and apex; style truncate, subequal in length to second joint.

Mesonotum black; brown pollinose, the narrow central and dorsocentral stripes and broad lateral margins, silvery gray pollinose. Short sparse hairs black; bristles black, two presutural, one or two supra-alar, one or two postalar and six dorsocentral. Pleurae silvery gray pollinose, fine hairs white, upper half of hypopleural fringe black. Scutellum gray pollinose with three (four, apparently one broken off) black marginal bristles.

Abdomen shining black; longer hairs laterally on first two segments and sparse fine hairs dorsally white, laterally on other segments short black; sides of first segment, posterior corners and anterior margins of segments 2 to 5, gray pollinose. Genitalia brown, black-haired.

Legs black, bristles black, fine hairs on the fore and middle legs white, on the hind legs largely black; claws and empodia black; pulvilli brown.

Halteres and alulae brown. Wings hyaline, veins dark brown, anterior crossvein beyond middle of discal cell.

Female: Length 8 mm. Differs from male as follows; Face not gibbous, mystax, frontal and occipital hairs black; face and frons yellowish gray pollinose, thin at the middle of the face. First antennal joint with four or five black bristle-like hairs below, style pointed apically. Light mesonotal pollen and pleural pollen, yellowish gray; humeri white-haired; hypopleural fringe white except the upper four or five hairs black; four scutellar bristles.

Holotype: Male, Mingus Mt., Ariz., July 3 '49 (J. Wilcox).

Allotype: Female, same data.

Paratypes: Ten males and 4 females, same data; same locality, 13 males and 3 females June 21 '49 and 4 females, July 3 '49 (C. H. and D. Martin). Three males and 5 females, Oak Creek Canyon, Ariz., July 9 '41 (R. H. Beamer), in the Snow Collection, University of Kansas.

Nannocyrtopogon minutus Wilcox and Martin

Nannocyrtopogon minutus Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 29: 455–456.

This species was described from three specimens collected in San Antonio Canyon in southern California, and has been taken in the following localities in southern California: South Fork, Santa Ana River, June 18 '45 (A. L. Melander) in Dr. Melander's collection; Camp Baldy, San Bernardino Co., July 22 '52 (J. H. Nakata) University of California (Davis); South Fork Camp, 6300′, San Bernardino Co., July 27 '41, July 3 '42, July 4 and 17 '43, July 7 '47 (Harold Hollingsworth, Guy F. Toland, C. H. Martin, J. Wilcox); Barton Flat, San Bernardino Co., July 13 '47 (Wilcox); and Bear Valley, Hanna Flat, San Bernardino Co., June 27 '48 (Wilcox), Aug. 31 '49 (Martin). The antennae are illustrated in fig. 1.

Nannocyrtopogon monrovia Wilcox and Martin

Nannocyrtopogon monrovia Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 29: 453–454.

This tiny species was described from specimens taken in Monrovia Canyon in Los Angeles Co., Calif. Additional specimens were taken in San Bernardino Co., Yucaipa, Calif., June 11 '47 (A. F. Howland and J. Wilcox). The antennae are illustrated in fig. 1.

Nannocyrtopogon neoculatus, new species

Male: Length 7 mm. Head black; face, ocellar tubercle and occiput gray pollinose; sides of face shining black; frons dull black. Face strongly gibbous, nine-tenths the width of one eye at the antennae. Tubercles "eye-like",

velvety black at middle and margined with yellowish pile, each in diameter equal to about one-third the width of the frons. Mystax black extending nearly to antennae with a few white hairs intermixed below; erect hairs on ocellar tubercle, shorter lateral tufts on eye margins opposite ocellar tubercle and beard, white; occipital bristles black. Antennae (fig. 2) black; first two joints subequal in length, black haired, the first with two weak and the second with one strong black bristle below; third joint twice as long as the first two joints together, slender in the middle, slightly enlarged basally and more abruptly enlarged apically; style short, about half the length of the second joint, truncate apically with evident spine.

Mesonotum black, gray pollinose, the central stripe and intermediate area brown; hairs white; bristles black, three or four presutural, one or two supra-alar, one postalar and seven or eight dorsocentral. Pleurae gray pollinose, hairs white, upper third of hypopleural fringe black. Scutellum gray pollinose with two or three short black discal hairs on either side, four strong black marginal bristles (may have been five, as one appears to have been broken off).

Abdomen black; white-haired, longer on the sides of the first two segments; sides of segments 1, 6, and 7, posterior corners of segments 2 to 5, and anterior margins of segments 2 to 7 gray pollinose. Genitalia black, white-haired.

Legs black, bristles black except four or five white ones posteriorly on the fore tibiae; sparse hairs white; claws and empodia black; pulvilli light brown.

Halteres dark brown; alulae brown, margin and fringe yellowish. Wings hyaline, veins dark brown, anterior crossvein at five-eighths the length of the discal cell.

Female: Length 7 mm. Differs from male as follows: Face not as gibbous and largely subshining black, mystax black. Tubercles densely gray pollinose anteriorly, dorsally slightly cupped and shining black. Ocellar tubercle with sparse white hairs and two or three erect black bristles. First antennal joint white haired below, black haired above; second with one strong black bristle below and two or three black hairs above; third of nearly uniform width but slightly enlarged apically and basally. Pollinose pattern confined to segments 1 to 5 of abdomen. Posterior fringe of bristles on fore tibiae black.

Holotype: Male, Pinyon Flat, Riverside Co., Calif., May 23 '48 (Guy F. Toland).

Allotype: Female, same data (J. Wilcox).

Paratypes: Eight males and 14 females, same locality and collectors, May 23 and 26 '48; same locality, 40 males and 43 females, May 9 to 11 '53 (C. H. and Dorothy Martin and Itol J. and J. Wilcox); and 1 male, Pinon Flat, San Jacinto Mts., Calif., May 15 '41 (E. C. Van Dyke), in California Academy of Sciences.

Very similar to and possibly only a variation of *oculatus* Wilcox and Martin. In addition to the key characters, *oculatus* males have the lower half of the mystax black and the upper half white with the exception of two black bristles; the black bristles in the mystax of *neoculatus* extend uniformly to the antennae; the erect white hairs on the ocellar tubercle of male *oculatus* are longer and curved laterally and in *neoculatus* are straight and of uniform height.

Nannocyrtopogon nevadensis, new species

Male: Length 9 mm. Head black, densely white pollinose; cheeks, palpi and proboscis shining. Face at antennae five-sevenths the width of one eye; ocellar tubercle one-third width of the vertex. Hairs and bristles, white; lower half of mystax and occipital bristles, black. First two antennal (fig. 2) joints subequal in length, white haired, the second with a long black bristle below; third coaretate, $1\frac{3}{4}$ times the length of the first two; style one-fourth length of the third joint.

Mesonotum black, densely gray pollinose; central stripe and intermediate spots, brownish. Hairs white; bristles black, three presutural, one or two supra-alar, two postalar and nine dorsocentral. Pleurae densely white pollinose, hairs white. Scutellum white pollinose with six strong black marginal bristles.

Abdomen black; hairs white, longer on the sides of the first two segments. White pollinose; sides of first segment, anterior margins and posterior corners of segments 2 to 6 broadly connected on 2 to 5 so that there is a central posterior and two lateral anterior black spots on these segments; the posterior spots narrowly reach the anterior margins laterally. Genitalia brownish black and white and black-haired.

Legs black; coxae white pollinose and haired; hairs short appressed white and rather dense; bristles black; claws black, reddish basally; pulvilli white, brownish centrally; empodium black.

Halteres brown; alulae brown, margin and fringe white. Wings lightly and evenly infuscated, veins dark brown, anterior crossvein at three-fifths length of the discal cell.

Female: Length 9 mm. Similar. Mystax largely black with shorter white hairs intermixed; bristles on ocellar tubercle, black; second antennal joint with two black bristles below. Mesonotal hairs black except anteriorly and on humeri. Upper half of hypopleural fringe black. Pollen on abdominal segment 5 interrupted and on segment 6 limited to posterior corners.

Holotype: Male, Walley Hot Spr., 3 mi. S. of Genoa, Douglas Co., Nev., June 24 '53 (A. A. Grigarick) University of California (Davis).

Allotype: Female, same data (R. M. Bohart) University of California (Davis).

Paratypes: One male, 6 females, same data

and collectors and (R. C. Bechtel). On all but one of the female paratypes the anterior pollinose bands on the abdomen are separated from the posterior lateral spots on all segments.

These specimens are labeled "Valley Hot Springs, Douglas Co., Nev." R. M. Bohart kindly gave the corrected locality.

Nannocyrtopogon nigricolor (Coquillett)

Cyrtopogon nigricolor Coquillett, 1904, Proc. Ent. Soc. Washington 6: 183.
Cyrtopogon nigricolor Back, 1909, Trans. Amer. Ent. Soc. 35: 284.
Cyrtopogon nigricolor Melander, 1923, Psyche 30: 110.
Nannocyrtopogon nigricolor Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 29: 457–458.

Additional specimens have been taken in the following localities in Southern California: Samuel Spr., Napa Co., May 15 '51 (E. I. Schlinger); Camp Baldy, San Bernardino Co., July 7 '52 (R. L. Anderson and J. H. Nakata); Tanbark Flat, Los Angeles Co., July 8 '52 (R. M. Bohart, E. M. Evans, D. E. Barcus); July 12 '52 (R. L. Anderson), and June 27 '55 (F. X. Williams and E. I. Schlinger); University of California (Davis). Camp Baldy, San Bernardino Co., July 7 & 8 '52 (B. Tinglof and R. E. Wagner); Beverly Glen Can., Santa Monica Mts., Los Angeles Co., May 17 '52; and Placerita Cn., Los Angeles Co., April 22 '39; University of California (Los Angeles). Wheeler Springs, Ventura Co., May 4 to 25 '41 (M. W. Stone, Guy F. Toland, J. Wilcox), Sierra Madre, May 16 '41 and June 28 '42 (Wilcox); Newhall, April 8 '34 (Stone); and Oak Flat Forest Camp, Angelus Natl. For., May 13 '56 (Wilcox). The antennae are illustrated in fig. 2.

Nannocyrtopogon nitidus, new species

Male: Length 6 mm. Head black; face and occiput gray pollinose, frons subshining black and to the sides of the antennae shining black. Face swollen, at the antennae five-eighths the width of one eye. Mystax black, hairs on the frons and ocellar tubercle in part black, above on ocellar tubercle white; occipital bristles black; beard white. Antennae (fig. 2) black; first two joints subequal in length, the first with three longer black hairs below and shorter ones above, the second with one black bristle below; third joint 1⅓ times the length of the first two joints together, slightly narrowed on the basal third; style slender, subequal in length to the second joint.

Mesonotum black; yellowish gray pollinose, the central stripe and intermediate area brown. Erect hairs black (on humeri white); bristles black, three presutural, one supra-alar, one or two postalar, and six or seven dorsocentral. Pleurae yellowish gray pollinose, hairs white, upper two-thirds of hypopleural fringe black. Scutellum yellowish gray pollinose with five black marginal bristles (six, apparently one broken off).

Abdomen shining black; sides of the first segment, posterior corners of segments 2 to 7, and anterior margins of 2 to 6 (6 narrowly), gray pollinose. Hairs white, longer on sides of the first two segments. Genitalia black and black-haired.

Legs black; hairs white; bristles black, fore tibiae and metatarsi with a sparse dorsal and posterior fringe, in average length equal to the diameter of the segment but gradually becoming longer apically on the tibiae. Claws black, lighter basally; empodia black; pulvilli brown.

Halteres brown; alulae brown, margin and fringe lighter brown. Wings lightly and evenly infuscated, veins dark brown, anterior crossvein at middle of discal cell, third vein branched well beyond discal crossvein.

Female: Length 7 mm. Similar. Style one-third the length of the third antennal joint. Upper three-fourths of the hypopleural fringe black; six scutellar bristles. Pollinose pattern confined to segments 1 to 5 of abdomen. Posterior fringe of bristles evident on fore tibiae but not on tarsi. Anterior crossvein at five-ninths the length of the discal cell.

Holotype: Male, Snow Valley, Big Bear Lake, Calif., June 27 '48 (Guy F. Toland).

Allotype: Female, same data (J. Wilcox).

Paratypes: Seven males and 2 females, same data and collectors.

Nannocyrtopogon oculatus Wilcox and Martin

Nannocyrtopogon oculatus Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 29: 452–453.

Female: Length 7 mm. Face not as gibbous as in male, mystax largely black but with fine white hairs intermixed, face at the antennae subequal to the width of one eye, gray pollinose. Frons and ocellar tubercle thinly gray pollinose, subshining black, contrasting with the face, sparse hairs white; tubercles small, situated slightly above the antennae at the eye margins; Ocellar tubercle about half the width of the frons at the vertex and with six weak black bristles. First two antennal (fig. 2) joints without strong black bristles below, third joint 2½ times the length of the first two joints together. Mesonotal hairs white, upper four-fifths of hypopleural fringe black, lower fifth white; six strong black marginal scutellar bristles. Sides of first abdominal segment, narrow anterior margins and posterior corners of segments 2 to 5 gray pollinose. No white bristles on anterior tibiae and tarsi.

Neallotype: Female, Palmdale, Calif., May 23 '42 (Guy F. Toland).

Other specimens of both sexes, same locality, May 10 '41, May 23 '42, May 2 and 29 '48 (Guy F. Toland, Itol J. and J. Wilcox).

The specimens were collected 4 miles south of Palmdale at the north end of Mint Canyon. The holotype male bore two locality labels—Lost

Hills, Kern County, Calif., April 11 '32 and Mint Cn., Calif., April 20 '32 (E. P. Van Duzee). It seems likely that Mint Canyon is the type locality.

Nannocyrtopogon richardsoni, new species

Male: Length 7 mm. Head black; face and frons apparently gray pollinose (somewhat greased); face strongly gibbous and at the antennae subequal to the width of one eye; mystax black. Tubercles triangular in shape, velvety black, the outer margin yellowish pilose, extending half way to the ocellar tubercle and slightly extending over the eye margins; ocellar tubercle two-thirds the width of the frons at the vertex and with a dense brush of erect black hairs, eye margins opposite ocellar tubercle with a dense clump of curved black hairs; occipital bristles black; beard white. Antennae (fig. 1) black; first joint slightly longer than second, both black haired, the first with two or three black bristles below and the second with one; third joint nearly twice the length of the first two joints together, of nearly uniform width but slightly narrower at the apical two-thirds; style minute, about half the length of the second joint.

Mesonotum black; gray pollinose, the central stripe and intermediate area brown. Hairs white; bristles black, two presutural, one supra-alar, one postalar and five dorsocentral. Pleurae gray pollinose and white haired, hypopleural fringe white. Scutellum gray pollinose with five black marginal bristles.

Abdomen black; hairs white, longer on the sides of the first two segments. Sides of the first segment, posterior and anterior margins of segments 2 to 7 gray pollinose, posterior bands interrupted at middle by about one-third the width of the segments. Genitalia brown, white haired.

Legs black, bristles black, hairs white; fore tibiae and tarsi with dense recumbent white hairs and fore tibiae posteriorly with a row of white bristles. Claws and empodia black, pulvilli brown.

Halteres brown; alulae brown, margin and fringe yellowish. Wings hyaline, veins dark brown, anterior crossvein slightly beyond middle of discal cell, third vein branched beyond discal crossvein.

Holotype: Male, Richardson's Springs, Butte Co., Calif., May 12 '44 (E. C. Van Dyke), in the California Academy of Sciences.

Nannocyrtopogon sequoia, new species

Male: Length 7 mm. Head black, gray pollinose, hairs white except a few intermixed in mystax, beard white. Face at antennae two-thirds the width of one eye. First and second antennal (fig. 2) joints subequal in length, the third 1½ times the length of the first two joints together, style one-third the length of the third joint; first joint white haired below and black haired above, second joint black haired with one or two slender long black bristles below.

Mesonotum gray pollinose, with intermediate spots and median stripes brown. Hairs and bristles black, three presutural, two supra-alar, two postalar and three posterior dorsocentral. Pleurae grayish golden pollinose, hairs white, hypopleural fringe black with lower fourth white. Scutellum grayish golden pollinose with six strong black marginal bristles.

Abdomen shining black, posterior corners of segments 1 to 6, anterior corners of segment 2 and anterior margins of segments 2 to 5 narrowly, gray pollinose. Hairs on sides of first two segments long white, otherwise short black. Genitalia black, black haired.

Legs black, hairs white except on hind tibiae and tarsi, black; bristles black, the fore tibiae with a rather dense dorsal and posterior fringe. Claws black; pulvilli light brown; empodia brown.

Halteres brown, the knob wine red; alulae brown, margin and fringe white. Wings brown, very lightly crimpled, veins brown, anterior crossvein at three-fifths the length of the discal cell, third vein branched beyond discal crossvein.

Female: Length 8 mm. Similar. A few white hairs in middle of frons. Eight scutellar bristles. Lateral spots on abdomen limited to segments 1 to 5, short fine hairs, white. Fringe of bristles on fore tibiae not so dense.

Holotype: Male, Sequoia Park, Calif., June 25 '48 (J. Wilcox).

Allotype: Female, same data.

Paratypes: Twenty-six males and 9 females, same data, June 22 to 25 '48, and 12 males and 5 females, Grant Grove, Calif., June 24 '48 (J. Wilcox, Jr. and J. Wilcox); 1 male and 4 females, Gen. Grant Park, Calif., June 6 '23 (M. E. Philips), University of California (Los Angeles).

Nannocyrtopogon stonei, new species

Male: Length 5 mm. Head black, densely grayish white pollinose; the central part of the face narrowly divided by a vertical pollinose line, shining. Mystax black interspersed with long white hairs especially on the sides and above; frons with short white hairs on the sides and at the center; ocellar tubercle with two or three long black and two or three long white hairs on either side and with short white hairs anteriorly; occipital bristles black; beard and hairs of palpi and proboscis white. Face strongly gibbous, a little more than three-fourths the width of one eye at the antennae; tubercle to the side of the antennae as large as the first antennal joint, frons only with deep grooves laterally; ocellar tubercle half the width of the frons at the vertex. Antennae (fig. 1) black; first two joints subequal in length and short white haired, each with a long black bristle below and the second with a short black bristle above; third joint 1⅓ times the

length of the first two joints together, rather wide and slightly coarctate; style cylindrical with an apical spine, about one-fourth the length of the third joint.

Mesonotum black; the humeri, broad lateral margins, narrow central and dorsocentral stripes, and transverse suture, gray pollinose, remainder brownish pollinose. Sparse hairs black, on the humeri white; bristles black, two presutural, one supra-alar, one postalar and about three dorsocentral. Pleurae black, gray pollinose, upper half of hypopleurals black, lower half white. Scutellum gray pollinose, with two strong black marginal bristles and two short black hairs on each side.

Abdomen black; sides of the first segment, the narrow anterior margins and posterior corners of segments 2 to 5, gray pollinose. Hairs white, short except on sides of first two segments and three white bristles on sides of first segment. Small genitalia brownish with short white hairs.

Legs black; coxae gray pollinose; hairs white, bristles black; fore tibiae and tarsi with dense, short, recumbent white hairs dorsally and posteriorly. Claws black with reddish bases; pulvilli whitish; empodia brown.

Halteres brownish black; alulae brownish, margin and fringe pale yellowish. Wings evenly and lightly infuscated, veins dark brown, anterior crossvein at middle of discal cell.

Female: Length 5 mm. Mystax and erect hairs on ocellar tubercle, black; tubercles smaller than in male but plainly evident; ocellar tubercle about one-third the width of the frons at the vertex. Hairs on humeri, black; upper four-fifths of hypopleural hairs black; four strong marginal scutellar bristles. Fore tibiae and tarsi with sparse, recumbent, white hairs. Anterior crossvein at two-fifths the length of the discal cell.

Holotype: Male, Wheeler Springs, Ventura Co., Calif., May 16 '42 (J. Wilcox).

Allotype: Female, same data.

Paratypes: Seventy-seven specimens both sexes, same data (M. W. Stone, Guy F. Toland and Wilcox) and same locality, May 25 '41 (Wilcox).

Named in honor of Marshall W. Stone, who first collected in this locality and who has collected Asilidae for us for many years.

Nannocyrtopogon timberlakei, new species

Male: Length 8 mm. Head black; face densely white pollinose; margins of frons thinly gray pollinose except narrowly before ocellar tubercle where it is velvety black; occiput gray pollinose. Mystax white, black on the sides of the oral margin and with four black bristles above; frons laterally with dense white hairs and several black ones intermixed; ocellar tubercle with a dense brush of erect white hairs; occipital bristles black; beard and hairs of palpi and proboscis white. Face not as gibbous as related species and at the antennae subequal to the width of one eye; tubercles elevated to height of first antennal joint and extending from eye margin to base of antennae, velvety black at center and margined externally and above with short white pile; ocellar tubercle shining black, three-sevenths the width of the frons at the vertex. First and second antennal (fig. 1) joints short, about as broad as long, the second joint reddish, remainder of antennae black, very short hairs white, first joint with one or two short weak black bristles below and the second with a long strong one; third joint slender, somewhat coarctate and nearly three times the length of the first two joints together; style about one-fourth the length of the third joint, truncate at apex and with apical spine.

Mesonotum black; sides and anteriorly grayish pollinose, the narrowly bisected central stripe and the intermediate stripes brown pollinose. Rather long hairs, white; bristles black, two presutural, one or two supra-alar, one postalar, and three or four dorsocentral. Pleurae gray pollinose and white haired, two or three hairs above in hypopleural fringe brownish. Scutellum gray pollinose with five strong black marginal bristles and about six fine white hairs on either side of disc.

Abdomen black; sides of the first segment and the anterior margins connected to the posterior corners of the remaining segments, gray pollinose, leaving a broad triangular spot posteriorly and anterior lateral black spots on segments 2 to 4, bands interrupted on segment 2 and segments 5 to 7 pollinose except for posterior margins. Hairs white, longer on sides of first two segments. Small genitalia black, white haired.

Legs black, coxae gray pollinose and white haired; bristles black except a double row posteriorly on the fore tibiae and two or three below on middle tibiae, white; hairs white; claws black with reddish bases; pulvilli white; empodia brown. Recumbent white hairs rather dense on all legs, especially on the tibiae and tarsi.

Halteres brownish black; alulae brown, margin and fringe whitish. Wings hyaline, veins dark brown, anterior crossvein at middle of discal cell.

Female: Length 9 mm. Similar. Mystax black with finer white hairs intermixed. Frons, tubercles and ocellar tubercle, gray pollinose; tubercles hardly evident extending narrowly up on frons; ocellar tubercle with six erect black bristles and a rather dense clump of shorter erect white hairs; hairs on eye margins sparse white with four or five black ones opposite ocellar tubercle. Scutellum with six strong black marginal bristles. Pollinose pattern confined to segments 2 to 5 of abdomen, disconnected on segment 2 and narrowly connected on segment 3. Tibial bristles black.

Holotype: Male, Oro Grande Wash, 11 miles

S. of Adelanto, Calif., May 9 '48 (P. H. Timberlake), University of California (Riverside).

Allotype: Female, same data, University of California (Riverside).

Paratypes: Six males and 4 females, same data; University of California (Riverside); 1 male, 2 females, Cajon Pass, San Bernardino Co., Calif., May 20 '51 (R. C. Bechtel) University of California (Davis); 56 males and 61 females, type locality, May 6 '56 and 1 male, Little Rock, Calif., May 3 '41 (J. Wilcox).

Nannocyrtopogon tolandi, new species

Male: Length 6 mm. Head black, densely white pollinose, the frons at certain angles dull black. Mystax and occipital bristles black, hairs otherwise white, a few in mystax white. Face at antennae three-fifths width of one eye, frons opposite antennae with a faint suggestion of a tubercle. First two antennae (fig. 1) joints subequal in length, the third 1⅓ times the length of the first two, style one-third the length of the third joint, first two joints short white haired above, first joint with two bristles and several black hairs below, second joint with one black bristle below.

Mesonotum black, grayish golden pollinose. Hairs white; bristles black, two or three presutural, one or two supra-alar, one or two postalar, and seven or eight dorsocentral. Pleurae grayish golden pollinose and white haired. Scutellum gray golden pollinose with two black marginal bristles.

Abdomen black, posterior corners of segments 1 to 6 and narrow anterior margins of segments 2 to 5, white pollinose; hairs white. Genitalia black and black haired.

Legs black, bristles black, fore and middle tibiae and tarsi with rather dense short erect white hairs, hind tibiae largely and tarsi black haired, femora white haired; claws black, empodia and pulvilli brown.

Halteres brown; alulae brown, margin and fringe white. Wings hyaline, veins dark brown, anterior crossvein at middle of discal cell, third vein branched beyond discal crossvein.

Female: Length 7 mm. Similar. Erect hairs on ocellar tubercle, black. Hairs on humeri and anteriorly on mesonotum white, otherwise black. Upper two or three hairs of hypopleural fringe black. Pollinose pattern on abdomen limited to segments 1 to 5.

Holotype: Male, Lone Pine, Inyo Co., Calif., May 30 '48 (J. Wilcox).

Allotype: Female, same data (Guy F. Toland).

Paratypes: Thirty-three males and 21 females, same data (Toland and Wilcox); 9 males and 7 females, same locality, June 10 '49 (Wilcox); 8 males and 4 females, Bishop, Calif., June 11 '49 (Toland and Wilcox); 57 males and 58 females, Bigpine, Inyo Co., Calif., May 18 '56 (Itol J. and J. Wilcox) and 3 males and 5 females, Independence, Inyo Co., Calif., May 18 '56 (Wilcox). Two males and 3 females, Lone Pine, Calif., Whitney Road, June 12 and 17 '37 (E. C. Van Dyke), in the California Academy of Sciences.

Named in honor of Guy F. Toland enthusiastic collector of Asilidae.

Nannocyrtopogon vanduzeei Wilcox and Martin

Nannocyrtopogon vanduzeei Wilcox and Martin, 1936, Ann. Ent. Soc. Amer. 29: 451–452.

Male: Length 8 mm. Similar to female. Mystax composed of about half white and black hairs, face more gibbous and at the antennae subequal to the width of one eye; tubercles opposite the antennae higher than the first antennal joint and extending over the eye margin, densely whitish pilose; frons narrowly, transversally above the antennae, velvety black, otherwise densely gray pollinose; ocellar tubercle with a clump of six long bent white vertical hairs on either side. Third antennal (fig. 2) joint twice the length of the first two joints together, first joint with long white hairs below and short hairs above, second joint with a black bristle below and short white hairs above. Mesonotal hairs white; upper half of hypopleural hairs black and lower-half white; five strong black marginal scutellar bristles. Pollinose anterior fasciae on segments 2 to 6 connecting with the posterior pollinose spots, segments 7 to 8 and dorsum of genitalia wholly pollinose; genitalia black, white haired. Fore tibiae and metatarsi with fine, rather dense, recumbent white hairs dorsally; fore tibiae with a double row of eight or nine white bristles posteriorly; middle tibiae with four long white ventral bristles and hind tibiae with three or four short white bristle-like hairs below. Anterior crossvein at five-ninths the length of the discal cell.

Neallotype: Male, Piru, Ventura Co., Calif. (the type locality), May 16 '42 (Guy F. Toland).

Other specimens, both sexes, same data (Toland and Wilcox).

Nannocyrtopogon vandykei, new species

Male: Length 7 mm. Head black; gray pollinose, the face subshining; the frons and ocellar tubercle dull. Mystax black with about six finer white hairs in the upper part; hairs of frons and ocellar tubercle black except for a few crinkly white hairs at center of frons; occipital bristles black; beard and hairs of palpi and proboscis, white. Face slightly gibbous, at the antennae about four-fifths the width of one eye; frons at vertex subequal to the width of one eye and with a small polished spot to the sides of the antennae but no tubercle; ocellar tubercle not prominent and about two-fifths the width of the frons at the vertex. Antennae (fig. 2) black; first joint slightly longer than second, short white haired and each with a long black bristle below; third joint 1½ times the length of the first two joints

together, slender, slightly larger at base and apex and bent to a slight angle apically; style one-third the length of the third joint, tapering to a point apically and with an apical spine.

Mesonotum black; brown pollinose, the lateral margins and narrow dorsocentral stripes, grayish. Hairs on humeri and anteriorly white, otherwise black; bristles black, three presutural, three supra-alar, two postalar and eight or nine dorsocentral. Pleurae grayish golden pollinose, hairs white, about upper fourth of hypopleurals black. Scutellum gray pollinose with five strong black marginal bristles.

Abdomen black; sides of first segment, narrow anterior margins and small posterior lateral spots on segments 2 to 7, gray pollinose. Hairs white, longer on sides of first two segments. Genitalia black, short white haired.

Legs black; coxae gray pollinose; hairs white; bristles black; claws black, reddish at base; pulvilli brown; empodia brown. Hairs or bristles not especially abundant or conspicuous on any segments.

Halteres brown; alulae brown, margin and fringe yellowish white. Wings lightly infuscated, veins brown, anterior crossvein at four-sevenths the length of the discal cell.

Female: Length 8 mm. Similar. Face at antennae two-thirds the width of one eye. More white hairs intermixed in mystax and upper third of hypopleurals black. Pollinose fasciae and lateral posterior spots confined to segments 2 to 5 of abdomen. Anterior crossvein at two-thirds the length of the discal cell.

Holotype: Male, South Fork Camp, 6000 feet, San Bernardino Co., Calif., July 17 '43 (J. Wilcox).

Allotype: Female, same data.

Paratypes: Twelve males and 9 females, same locality, July 26 '41, July 3 and 12 '42 and July 4 '43 (Guy F. Toland, C. H. Martin, J. Wilcox); Sierra Madre, Calif., May 17 '41 (Wilcox); Big Bear Lake, Hanna Flats, Calif., July 31 '49 (C. H. and Dorothy Martin). One female, Forest Home, San Bernardino Co., Calif., June 19 '28 (E. C. Van Dyke), in the California Academy of Sciences. One female, South Fork. Santa Ana River, Calif., August 4 '45 (A. L. Melander), in the Melander collection. One male, Glendale, Los Angeles Co., Calif., July 21 '52 (W. M. Schlinger); 1 male, Crystal Lake, Los Angeles Co., Calif., June 29 '50 (F. X. Williams); and 1 female, June 9 (R. M. Bohart), University of California (Davis).

This species is only one of a number of species of this genus first collected by the late E. C. Van Dyke. It is a privilege to name this species in honor of a man who contributed so much to our knowledge of the insects of the Western States.

REFERENCES CITED

James, M. T. 1942. Additions to the "Robber Flies of Colorado." Jour. Kans. Ent. Soc. 15(4): 124–6.

Wilcox, J., and **C. H. Martin.** 1936. A Review of the Genus Cyrtopogon Loew in North America (Diptera-Asilidae). Ent. Amer. 16 n.s. (1): 1–95.

1936. The Genus Nannocyrtopogon (Diptera, Asilidae). Ann. Ent. Soc. America 29(3): 449–59.

1957. Backomyia (Diptera-Asilidae), a new genus. Jour. Kans. Ent. Soc. 30(1): 1–5.

OVIPOSITION RESPONSE OF LIMONIUS AGONUS (SAY) (COLEOPTERA, ELATERIDAE) TO SAND PARTICLE SIZE[1]

JAMES B. KRING

The Connecticut Agricultural Experiment Station, New Haven

The eastern field wireworm, *Limonius agonus* (Say), is normally found in large numbers in continuously cropped, fine sandy soils. Infestations may further be confined to the sandier portions of a given field. By contrast the wheat wireworm, *Agrioles mancus* (Say), is normally found in large populations only in heavier sod soils. No instance of mixed populations of these two species are recorded although heavy infestations may occur within a few miles of each other. Rawlins (1940) noted the distinctions between these two species.

Field and laboratory studies indicate that with *L. agonus* this restriction to fine sandy soils is not the result of survival of larvae only in the sandy areas, but rather an expression of selection of these soils for oviposition. Unpublished data of Olson (1946) support this conclusion.

Differences in temperature, available moisture, growing crops, crop residues, and the physical appearance (color) between areas infested and those not infested by *L. agonus* that might

[1]Accepted for publication Oct. 30, 1956.

influence oviposition site choice by these beetles were considered and tested in the laboratory. None of these gave a clear cut or consistent response that could be related to the choice as found in nature.

Subklew (1934) has pointed out that larvae of *Agriotes obscurus* Linn. were strongly positively thigmotactic—moving to places of most body contact. If it is assumed that the physical contact expression by *A. obscurus* larvae also obtains for adults of this and other species of Elateridae, it should be possible to demonstrate this reaction by determining the oviposition response of the adult click beetles when they are presented with a choice of situations in which the amount of physical contact with the oviposition site is controlled.

Adult *L. agonus* females usually dig to penetrate the surface of the soil to oviposit. In the act of tunnelling, the beetles use the head capsule, the first pair of legs, and the mouth parts in manipulating individual particles. The latter two pairs of legs are used as levers in forcing the body into the soil. *A. mancus* usually enters soil crevices and cracks for oviposition (Hawkins 1936).

METHODS

To demonstrate the thigmotactic response of adult click beetles of these species use was made of anaerobic Bray chambers as oviposition site choice chambers (Kring 1955). In these chambers, adults were presented in replicated tests with a choice between fine and coarse sands. Sands of known particle size were obtained by screening washed sand through a standard series of screens. The smaller the sand particle, the greater the number of particles in a given volume and thus, the greater number of physical contacts to any body part in contact with the sand.

The two separate compartments within these chambers allow for sands of two different sizes to be tested in each chamber. Twenty milliliters of sand, moistened with two milliliters of water, were used in each compartment of the test chamber. Male and female beetles were introduced into the chamber, and the whole covered to exclude light and to reduce evaporation. After each period of exposure, the amount of disturbance in each compartment was noted. Exposure periods ranged from 24 to 168 hours depending on the oviposition activity of the female beetles.

These tests were run at high moisture levels to reduce the movement of the adults that would result from confinement in the test chamber. Lees (1944) pointed out that activity of *Agriotes* spp. was slowed as the moisture holding capacity of sand neared saturation.

Eggs were recovered from the test sands by flotation with saturated salt solutions and by washing through screens. In most instances, several washings were necessary to recover all eggs. Examination of the sands under a binocular microscope after washing recovered eggs encrusted with sand.

TABLE I

OVIPOSITION RESPONSE OF *Limonius agonus* (SAY) AND *Agriotes mancus* (SAY) TO SAND PARTICLE SIZE

	Size of Sand Particles Offered for Choice*	Ave. No. Eggs per Test	
		Fine Sand	Coarse Sand
L. agonus	.16 mm vs. 2.00 mm in dia	130	2
	.21 " " 2.00 " " "	141	0
	.51 " " 2.00 " " "	7	0
	.72 " " 2.00 " " "	46	0
	2.00 " " 2.00 " " "	67	46
A. mancus	.16 " " 2.00 " " "	0	0
	.72 " " 2.00 " " "	0	0

*Approximate sand particle sizes obtained by screening sand through a standard series of brass sieves.

Once a female beetle begins oviposition, it will be continued even on moist filter paper in a petri dish until the beetle is subjected to adverse conditions. To prevent obscuring of results, it was necessary to subject beetles to dry or cold conditions before placing them in the next choice situation.

RESULTS

When presented with a choice situation between fine and coarse sand, gravid *L. agonus* adults chose for oviposition fine over coarse sands (Table I). When *A. mancus* was repeatedly presented with some of the same choices, no eggs were recovered. However, when *A. mancus* was presented with sands in which crevices had been made prior to the introduction of the adult beetles, the beetles oviposited.

When *L. agonus* was presented with either coarse or fine sand alone (i.e. no choice) eggs were recovered from both sides of the test chambers.

In constructing tunnels in the sand, *L. agonus* adults were observed to use their mandibles to manipulate individual sand particles. When presented with a choice between sands slightly larger and sands slightly smaller than the maximum mandibular opening, eighty-six per cent of the total eggs oviposited were recovered from the sands more easily moved with the mandibles. The activity of the adults was much greater in the finer sands.

Given a choice between two fine sands (.16 mm. vs .27 mm.), *L. agonus* adults chose the finer of the two sands for oviposition. Although the adult activity was essentially the same in both sands, ninety-five per cent of the eggs were recovered from the finer sand.

DISCUSSION

Two factors are considered operative in the choice selections made by *L. agonus* in these studies. The first is the response to maximum physical contact with the sand, a strong positive thigmotactic response. The second and less important is the relative ease of manipulations of smaller sand particles by the mandibles.

That *A. mancus* does not demonstrate a similar reaction in these tests is not considered to indicate that this species does not have a positive thigmotactic response.

L. agonus adults are better adapted in general body shape for penetration of the soil surface by digging than are *A. mancus* adults. (Fig. 1). The anterior end of the body of *L. agonus* adults is pointed in shape, while the same end of *A. mancus* is quite blunt. The mouth parts of *L. agonus* are capable of being extended forward through a greater arc than that possible for *A. mancus*.

The frons and clypeus of *L. agonus* form a well developed scraper-like projection. In the construction of a tunnel, this projecting frontal area is used as a scoop. These areas of the head of *A. mancus* present a smooth surface which by comparison would be less useful in digging.

FIGURE 1. Sharp vs. blunt anterior lateral profile of *Limonius agonus* (Say) (upper) compared with *Agriotes mancus* (Say).

CONCLUSIONS

In laboratory tests on the selection of oviposition site, it was possible to demonstrate that *Limonius agonus* (Say) responded positively to maximum contact with sand, a thigmotactic response. It was not possible to demonstrate similar reaction for *Agriotes mancus* (Say) by these tests.

It has also been demonstrated that in a situation where the insect is presented with a choice, *L. agonus* adults will choose for oviposition sands more easily manipulated with the mandibles.

REFERENCES CITED

Hawkins, J. H. 1936. The bionomics and control of wireworms in Maine. Maine Agric. Expt. Sta. Bull. 381. 146 pages.

Kring, James B. 1955. A chamber for studies of site selection by Elateridae. Ent. News 66(7): 187–9.

Lees, A. D. 1944. On the behavior of wireworms of the genus *Agriotes* Esch. (Coleoptera, Elateridae). II. Reactions to moisture. Jour. Exptl. Biol. 20: 54–60.

Olson, R. E. 1946. The biology of the eastern field wireworm, *Limonius agonus* Say, in western New York. Unpublished Master of Science Thesis, Cornell University. 60 pages.

Rawlins, W. A. 1940. Biology and control of the wheat wireworm, *Agriotes mancus* Say. Cornell Agric. Expt. Sta. Bull. 738. 30 pages.

Subklew, W. 1934. Reizphysiologisches Verhalten der Larvae von *A. obscurus* L. Zeitschr. vergl. Physiol. 21(2): 157–66.

ERRATA

In the second paragraph under "Discussion" on page 18 of Volume 50, the sixth line should read:
"and shows lesser sexual excitement than"

On page 246 of Volume 50, No. 3 in the second line of the second column of the Book Notice "scrophulaceous" should read "scrophulariaceous".

A FIRST RECORD OF SIMULIUM (EUSIMULIUM) CONGAREENARUM (D. & S.) FROM NEW YORK, WITH DESCRIPTIONS OF THE MALE, FEMALE, PUPA, AND LARVA[1]

HUGO JAMNBACK
New York State Science Service
AND
ALAN STONE
Entomology Research Branch, Agricultural Research Service, U. S. Department of Agriculture

Twenty-three species of black flies have been recorded from New York State (Stone and Jamnback, 1955). In 1955 a hitherto unrecorded species was collected on Long Island, increasing the number to twenty-four. A redescription of the female and first descriptions of the male, pupa and larva of this species are presented below. The characters used in the descriptions are discussed in the publication cited above.

Simulium (Eusimulium) congareenarum (Dyar & Shannon)

Eusimulium congareenarum Dyar and Shannon, 1927, Proc. U. S. Nat. Mus. 69(10): 20.

Male: Body length and wing length about 2.5 mm. Antenna 11-segmented, uniformly brownish. Holoptic. Clypeus dark brown with gray pubescence and light hairs. Maxillary palpus brown; segment length ratios from base to apex 3–3–8–12; sensory organ on basal half of third segment, round in outline, diameter about one-fifth length of segment.

Mesonotum velvety black with short recumbent golden hairs. Scutellum dark brown; with long erect, mostly golden hairs. Postnotum velvety black, appearing grayish in certain lights because of a fine pale pubescence. Pleuron brown with grayish pruinosity. Pleural tuft pale. Wing with hairs on stem vein and base of costa black. Subcosta and base of radius with setae dorsally and ventrally. First and second basal cells present although second cell may be indistinct. Halteres brown. Legs with coxae and trochanters brown; femora with indistinct apical darkening; tibia darkened basally and apically, tarsi darkened. Hind basitarsus about five times as long as wide; calcipala present; second tarsal segment with moderately developed pedisulcus (fig. 1a). Claws with short inconspicuous basal tooth (fig. 1b).

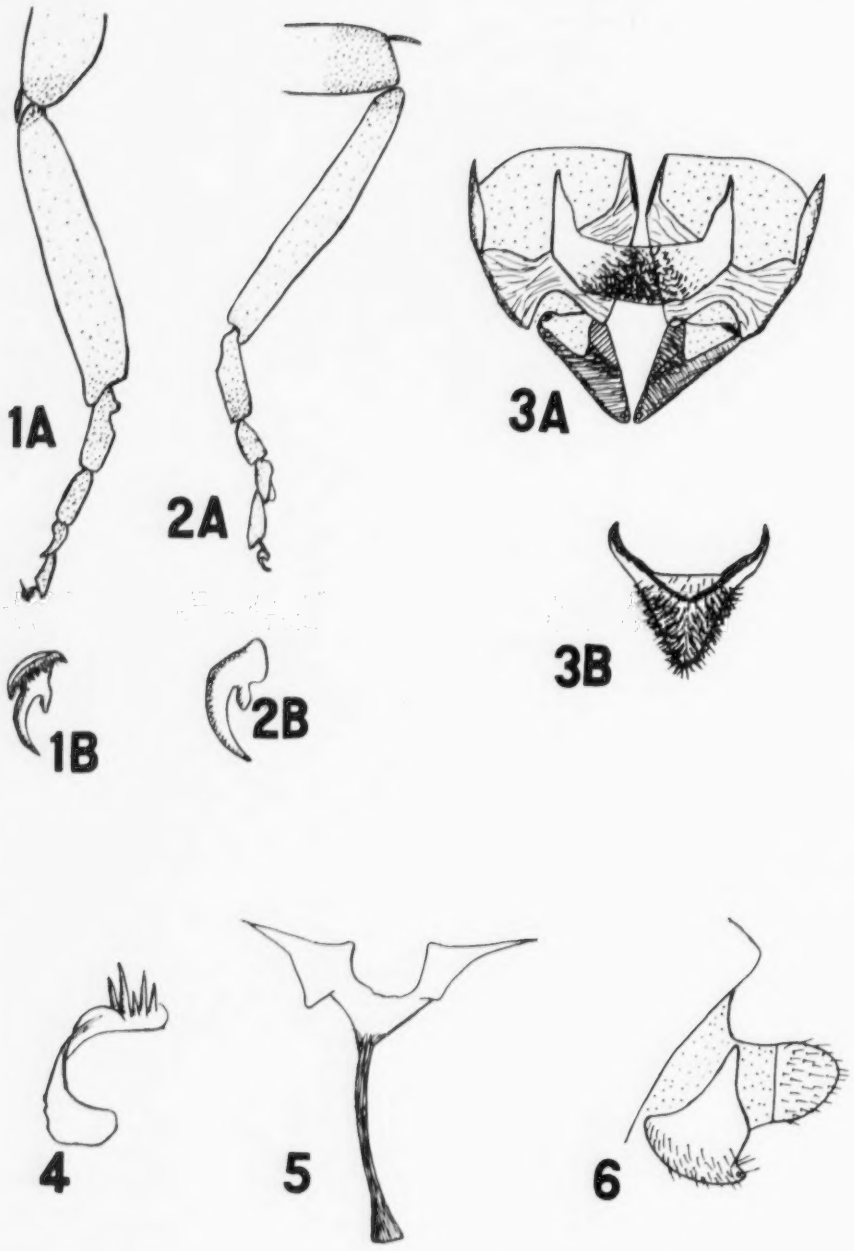
Basal fringe dark brown. Tergites and sternites velvety dark brown. Genitalia: Basistyle slightly longer than dististyle (fig. 3a). Basistyle subquadrate. Dististyle conical with one small apical tooth. Ventral plate (adminiculum) broader than long when viewed dorsally or ventrally, with short, tapering, anteriorly projecting arms which lack lateral projections. When the ventral plate is viewed from the side, front, or back a broad setose median ventral keel may be seen (fig. 3). Median sclerite not visible as a strongly sclerotized Y-shaped structure as found in *S.* (*E.*) *gouldingi*, *S.* (*E.*) *latipes*, or *S.* (*E.*) *pugetense*. Parameral arms each bearing about five well-sclerotized parameral teeth (fig. 4).

Female: Body length and wing length about 2.5 mm. Antenna 11-segmented, scape and pedicel light brown, flagellum dark brown. Dichoptic. Frons at narrowest about seven-tenths width of clypeus, widened above. Frons and clypeus dull black with gray hairs and grayish pollinosity. Mandibles serrate; maxillae with retrorse teeth. Maxillary palpus brown with pale hairs; segment length ratios base to apex 3–3–10–10–15, sensory organ on basal half of third segment, oval in outline, longest axis about one-fourth as long as segment.

Mesonotum dull black with gray pollinosity and pale recumbent hairs. Scutellum dark brown with long erect mixed pale and dark hairs. Postnotum dark brown, appearing golden in certain lights because of a fine golden pubescence. Wing with second basal cell poorly developed, usually incomplete on outer posterior margin. Legs, light yellow brown, except for the middle and hind coxae, the apical fifth of the femora, the base and apex of the tibiae, and the tarsi which are somewhat darkened. Hind basitarsus about six times as long as wide; calcipala present; second tarsal segment with poorly developed pedisulcus (fig. 2a). Claws with a basal tooth about one-third as long as claw (fig. 2b).

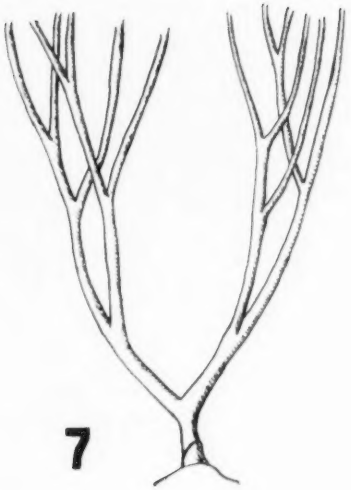
Basal fringe and hairs of abdomen pale. Tergites 2 to 9 with sclerotized plates gradually widening posteriorly, subshining. Sternites 1 to 6 membranous, sternite 7 lightly sclerotized, sternite 8 with a darkened, sclerotized plate. Genital fork with median rod sclerotized, widening slightly anteriorly, with distal ends of the arms expanded subtriangular, tapering toward the tips (fig. 5). Ovipositor valves small, subtriangular, not expanded posteriorly, mostly membranous except for light sclerotization on mesal margin. Anal lobe narrowed dorsally, widened ventrally with a posteroventral projection as in fig. 6. Cercus rounded posteriorly, flattened anteriorly.

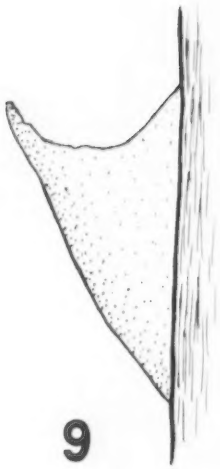
[1]Published by permission of the Director, New York State Museum and Science Service, Journal Series No. 17. Accepted for publication Nov. 6, 1956.



List of Figures of *Simulium* (*Eusimulium*) *congareenarum* (D. & S.)

FIG. 1. A., Hind tarsus ♂, lateral aspect; B., claw ♂, lateral aspect. FIG. 2. A, Hind tarsus ♀, lateral aspect; B, claw ♀, lateral aspect. FIG. 3. A, Genitalia ♂, dorsal aspect; B, ventral plate ♂, posterior aspect. FIG. 4. Paramere and parameral arms ♂, dorsal aspect. FIG. 5. Genital fork ♀, ventral aspect. FIG. 6. Anal lobe and cercus ♀, lateral aspect.





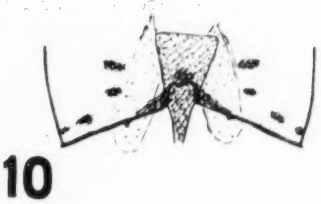


FIG. 7. Pupal respiratory filaments ♀, lateral aspect. FIG. 8. Pupal pelt ♂, lateral aspect. FIG. 9. Pupal cocoon ♂, lateral aspect. FIG. 10. Larval throat cleft, ventral aspect. FIG. 11. A, B, Inner subapical margin of larval mandibles showing variation in serrations, lateral aspect. FIG. 12. Larval antenna, lateral aspect.

Pupa: Length about 3 mm. Respiratory organ subequal in length to pupa, with 12 gradually tapering filaments arising from a short trunk which divides into two symmetrical branches; each of these branches gives rise to two sub-branches which in turn give rise to two smaller branches (fig. 7). The dorsum of thorax lacks striations but bears about six long simple trichomes on each side. In lateral aspect, the abdomen has a pattern of hooks and setae on each side distributed as follows: dorsally, four long setae near the posterior margin of segment 2; four stout anteriorly directed hooks near the posterior margin of segments 3 and 4; a series of posteriorly directed small hooks near the anterior margin of segments 6 to 9; segments 1 and 5 lacking dorsal hooks or setae. Ventrally, segments 5 to 7 bear two long seta-like hooks located as shown in fig. 8. The terminal hooks of the abdomen are short but distinct.

The cocoon is closely woven with a well defined, although uneven, anterior margin which is not thickened. It is wall-vase shaped with an anterior median projection (fig. 9).

Larva: Mature specimens 6 mm. long. Head capsule light yellow with dark brown head spots; lacking fulvous area around head spots; isthmus broad between anterior and posterior median groups; epicranial plate with paired ventrolateral spots on each side of throat cleft. Throat cleft an irregular, shallowly U-shaped notch with irregular flattened apex, (fig. 10), extending less than one-eighth distance from posterior margin of head capsule to tip of longest submental tooth. Suboesophageal ganglion distinctly black, connectives and supraoesophageal ganglion unusual in being distinctly visible as black structures in specimens preserved in alcohol. Submentum typical for genus; with nine teeth (excluding processes beyond two large lateral teeth); lateral margins serrate distally with distalmost serrations large and pigmented. One long and one short epicranial seta on each side. Distance from apex of outermost tooth of submentum to anteriormost seta on same side slightly more than distance between outermost teeth. Mandible with small teeth having relative lengths 15–12–9 from distalmost basad. Inner subapical margin of mandible usually with one or two large serrations extending at about right angles to mandible and three or four smaller, anteriorly directed, serrations (occasionally small accessory serrations also present, figs. 11a, b). Antenna almost as long as distance from insertion to posterior margin of head capsule; segment length ratios from base to apex 12–12–13–1; segment 1 yellowish, lightened ventrally; segment 2 light ventrally, yellow dorsally interrupted by 3 dorsal extensions of the light ventral area producing a banded effect; segments 3 and 4 uniformly yellow (fig. 12). Each cephalic fan with about 61 rays. Length of maxillary palpus about four times width at base. Pupal respiratory histoblasts each with 12 filaments. Abdomen of preserved specimens mottled reddish with lighter intersegmental areas. Abdomen with conspicuous paired ventral tubercles. Anal gill with three simple lobes. Anal cross-piece narrow with ventral arms slightly longer and wider than dorsal arms, area between dorsal arms lightly sclerotized. Anal hooks 8 to 10 per row in about 63 rows.

Discussion: Simulium (*Eusimulium*) *congareenarum* resembles the four other species of *Eusimulium* recorded from New York State. The adults differ from *S.* (*E.*) ***aureum*** Fries in lacking long recumbent setae on the postnotum. The males differ from *S.* (*E.*) ***aureum***, *S.* (*E.*) ***gouldingi*** Stone, *S.* (*E.*) ***latipes*** (Meigen), and *S.* (*E.*) ***pugetense*** (D. & S.) in the shape of the dististyle, in possessing more than one or two parameral hooks, and from the last three of these species in lacking a well sclerotized Y-shaped median sclerite. The females closely resemble *S.* (*E.*) ***gouldingi***, *S.* (*E.*) ***latipes***, and *S.* (*E.*) ***pugetense*** in the shape of the anal lobe and cercus.

The pupae are distinctive in possessing 12 pupal respiratory filaments and a cocoon with the anterior edge not thickened.

The larvae resemble *S.* (*E.*) ***aureum*** in possessing a simple anal gill while the other ***Eusimulium*** species possess compound anal gills. The pattern of the antenna and the dark suboesophageal ganglion serve to distinguish the larvae of this species from other ***Eusimulium*** occurring in New York.

Distribution: This species appears to be restricted to the eastern coastal plain. The original material consisted of females only, collected at Congaree, South Carolina. It is abundant in South Carolina and has been collected in Louisiana, Florida, Georgia, Virginia and Maryland. It probably reaches its northern limit in Long Island.

Collection Records: NEW YORK: Suffolk Co., Speonk, L. I., Seatuck Creek (east branch); April 22 (adults, pupae, larvae), April 29 (reared adults, pupae, larvae), June 23 (pupae, larvae). FLORIDA: Alachua Co., Lacrosse. GEORGIA: Chatham Co., Savannah, April 5 (adults). LOUISIANA: St. Tammany Par., Slidell, March 3 (adults). MARYLAND: Prince Georges Co., April 24 (pupae, larvae). SOUTH CAROLINA: Richland Co., Congaree (type locality) March 17, April 22 (adults); Clarendon Co., Manning, Feb. 22 (adults); Allendale Co., March 25 (pupae, larvae); Hampton Co., Feb. 8 (pupae, larvae); Jasper Co., Feb. 9 to March 18 (adults, pupae, larvae). VIRGINIA: Prince George Co., April 24 to May 17 (reared adults, pupae, larvae).

Biology: S. (*E.*) ***congareenarum*** appears to be rare in New York State. Larvae and pupae of this species were collected from only a single stream on Long Island. This stream, Seatuck

Creek, is about two feet wide and six inches deep in the sector where collections were made. It flows throughout the year. No other species of black fly was found breeding here. Specimens collected include numerous larvae, 14 pupae, 5 males and 2 females reared from pupae, and 3 females on the wing.

Jones and Richey (1956) report that *S.* (*E.*) ***congareenarum*** is the most common and widespread species present in streams in February in Jasper Co., S. C., and that the larval populations decrease greatly in numbers by May first. On Long Island larvae were abundant in April and much less common in June. They state that the adults feed on turkeys but are not annoying to humans. It is interesting to note that the stream on Long Island in which this bird-attacking species was found is in the area where most of the Long Island ducks are reared.

REFERENCES CITED

Jones, C. M., and **D. J. Richey.** 1956. Biology of the black flies in Jasper County, South Carolina, and some relationships to a *Leucocytozoon* disease of turkeys. Jour. Econ. Ent. 49: 121–3.

Stone, A., and **H. Jamnback.** 1955. The black flies of New York State (Diptera: Simuliidae). New York State Mus. Bull. 349: 1–144.

STUDIES ON THE COMPOSITION AND MICROBIOLOGY OF INSECT SPITTLE[1]

H. A. WILSON[2] AND C. K. DORSEY[2]
Morgantown, West Virginia

The production of spittle by nymphal Cercopidae is a natural phenomenon that has been observed by man for centuries though the source of spittle was a conjectural matter until late in the 17th century. Detailed studies of the principal workers in this field from late in the 19th century to the present time have been adequately cited by Weaver and King (1954) who also describe the manner in which the spittlebug nymphs mix air and anal liquid to form spittle.

The source of the liquid used in spittle formation is recognized as being the plant sap upon which spittlebugs feed. An excess amount of sap is ingested by the insects and is excreted from the anus copiously by nymphs and to a lesser degree by adults. Only nymphs produce spittle masses that completely surround their rather fragile bodies. This froth apparently provides protection against desiccation and may serve to prevent attacks from enemies; the nymphs soon die when deprived of the vital spittle.

A number of students of cercopids have observed the efficient manner in which the air bubbles are retained in the liquid from which the foam is formed. As Weaver and King (1954) have pointed out, there are four principal theories that attempt to explain this interesting phenomenon. Guilbeau (1908) demonstrated that the glands of Batelli are involved; Licent (1912) believed that a secretion from the Malpighian tubules helped to stabilize the air bubbles; Sule's (1911) explanation was that a fatty acid formed, as the result of the action of an intestinal tract enzyme on the secretion from the glands of Batelli, produces a substance that gives spittle soap-like properties; Cecil (1930) contended that the anal fluid alone, without additions from glands or other organs, had properties that would stabilize air bubbles incorporated in the liquid.

Osborn (1916) suggested that there was some substance present in the anal excretions of cercopids that aided in the maintenance of the frothy condition of the spittle. There have been some analyses of spittle by workers, but these have been concerned mainly with determining the water content and the presence of organic and inorganic substances. Licent (1912) found that cercopid spittle contained more water (99.44 vs. 94.57%), less organic matter (0.14 vs. 3.83%) and less inorganic material (0.38 vs. 1.60%) than the associated plant sap. Gruner's findings (1901) were similar with reference to the constituents in spittle and he pointed out that spittle also contained all of the substances excreted from the anus.

The economic importance of spittlebugs is now widely recognized, but this recognition was slow in making its appearance. Apparently most of the hosts upon which cercopids feed suffer damage in varying degrees. This damage may be physical, physiological or as the result of the introduction of a plant pathogen into the host; in some cases it results from a combination of these causes. Secrest (1944) reported serious

[1]Published with the approval of the Director of the West Virginia Experiment Station as Scientific Paper No. 544. Accepted for publication Dec. 10, 1956.

[2] [2]Associate Bacteriologist and Entomologist respectively, West Virginia Agricultural Experiment Station.

physiological injury to pines caused by the Saratoga spittlebug, *Aphrophora saratogensis* (Fitch.). Mundinger (1946) observed the devitalizing effect of spittlebug feeding on strawberry plants. Weaver and Hibbs (1952) found that spittlebugs reduce hay yield. Chandler (1953) determined that the pecan spittlebug is a serious pest on that host. Putnam (1939) believes that the meadow spittlebug is an important agent in the dissemination of the plum nursery mite, *Phyllocoptes fockeui* Nal. and Trt. Sanderson (1947) is of the opinion that salivary toxins of the Saratoga pine spittlebug injected into pines during feeding causes a breakdown of phloem tissue resulting in necrosis with which the fungus, *Chilonectria cucurbitula* (Curr.) Sacc., is associated. Gruenhagen *et al.* (1947) determined that the burn blight organism of pine is *C. cucurbitula* and that the disease commonly occurs in jack and red pine following attacks by the pine spittlebug, *Aphrophora parallela* (Say). Severin (1947) found that several species of spittlebugs are vectors of the virus that causes Pierce's disease in grapes; in 1950 he reported that the meadow spittlebug is an efficient vector of the same disease.

This present work is the result of the authors' interest in air bubble formation and retention in spittle and in the associated microorganisms. This interest included the consideration of bacteria and fungi as possible contributors to bubble formation and retention in spittle masses. Preliminary examinations of insect spittle revealed the presence of large numbers of bacteria. It was desirable to learn something about the characteristics, identity and associations of these bacteria with spittlebugs. Since the chemical nature of media sharply limits the existence and activity of most microbiological agents it was expedient to learn also something about the hydrogen ion concentration and the amino acid and sugar components of spittle for a better understanding of the relationships that exist between microorganisms and spittle. There was no information pertaining to these constituents and characteristics of insect spittle although Gray (1952) studied the amino acid and sugar components of anal excretions of pineapple mealy bugs. Weber (1930) made a similar study of the honeydew of a coccid and Kershaw (1914) analyzed the spittle of *Tomaspis saccharina* Dist. Ewart and Metcalf (1956) studied the sugars and amino acids in the honeydew of citrus feeding coccids. In the present studies isolations of microorganisms were made for identification purposes. Total counts of bacteria in spittle masses were also made and further bacterial counts were completed to determine whether the number of viable bacteria increased with the age of the spittle. Antifungal and antibacterial characteristics of spittle and microorganisms (included or experimentally added) were studied to learn more about the potentialities of spittlebugs as plant disease vectors.

MATERIALS AND METHODS

Spittle masses of the meadow spittlebug, *Philaenus leucopthalmus* (L.) were collected from field plants in sterile glass vials for microbiological studies. Spittle collected for chromatographic analysis was taken from both the meadow spittlebug and the pine spittlebug, *Aphrophora parallela* (Say) in clean, but not necessarily sterile glass containers.

Plant juices for pH determinations were obtained either by expressing the juice from plants with a hydraulic press or by grinding plant parts with a mortar and pestle in a small amount of distilled water. It was necessary to dilute the insect spittle with distilled water before making the determinations. A glass electrode was used in making all of the pH determinations (spittle and plant juice).

Paper chromatography provided information on the presence of sugars and amino acids in insect spittle and plant juices. Quantities of spittle masses were collected in the field for this purpose. In 1955 the nymphs were separated from the spittle by centrifuging, but in 1956 this was more easily accomplished by filtering the spittle through coarse filter paper or glass wool in a Buchner funnel. The spittle masses of the meadow spittlebug were mixed together in 1955 without regard to host plants. In 1956 the spittle from red clover, alfalfa, red, and Scotch pine were kept separate for analysis. The liquid spittle was divided into two portions; one portion was hydrolyzed by autoclaving for 1 hour at 15 lbs. steam pressure with 0.5N H_2SO_4. After hydrolysis the spittle was adjusted to pH 5 with $Ba(CO_3)_2$ and $Ba(OH)_2$; it then was filtered and concentrated under vacuum (Wise *et al* 1955). The upper phase from a mixture of n-butanol, glacial acetic acid and water (4:1:5 v/v) (Partridge, 1948) was the solvent used for the sugar determination. The spray reagent was 1% aniline hydrochloride in 95% ethanol (Kurasawa and Honma, 1952). The amino acid solvent was methyethyl ketone, propionic acid and water (7:2:5 v/v) (Claton and Strong, 1954); the spray was 0.1% ninhydrin in water-saturated n-butanol.[4]

Quantitative determinations were made of the bacterial content of spittle in its frothy condition since no way was found to free quickly the spittle of the incorporated air.

The bacterial growth in spittle was estimated after incubation periods of 0, 2, 3, and 5 or 0, 2, 3, and 6 days. A mixture of sterile, distilled water and spittle was placed in deep well slides. Each slide was then placed in a sterile petri dish lined with moistened filter paper. The numbers

[4]The authors appreciate the help of Mrs. Ruth Folmer in certain chemical and chromatographic aspects of these studies and also the assistance of Mrs. Julie Caravosas in parts of the microbiological investigations. The assistance of Dr. V. G. Lilly was particularly helpful in the interpretation of the chromatograms.

of bacteria were determined by serially diluting 0.01 ml. of the spittle-water mixture with sterile, distilled water and then making standard plate counts on nutrient agar after incubation at 28°C.

The effect of drying and subsequent storage at 28° and 37°C. upon the bacteria included in the spittle was studied. A loopful of spittle was placed on each of several ⅝ inch, weighed cover glasses and then the total weight of each was determined. These cover glasses were then placed in a desiccator under vacuum, in the presence of a drying agent. The cover glasses containing the desiccated spittle were then placed in sterile petri dishes in desiccators having an internal relative humidity of 20%. The desiccators were stored in incubators at 28°C. At intervals of 0, 3, and 11 weeks, a cover glass was aseptically removed from each desiccator and placed in a 250 ml. Erlenmeyer flask containing sterile, distilled water. The flask was shaken to disperse the bacteria; the mixture was then serially diluted and standard plate counts were made on nutrient agar, after incubation for 6 days at 28°C. (Leach *et al.* 1956).

The cylinderplate method was used in a study of antifungal and antibacterial properties of freshly collected spittle. Fragmented mycelium of each fungus tested was transferred into yeast extract agar and then added to petri dishes. Plates of nutrient agar seeded with 18 to 24 hour old bacterial cultures were poured for comparable antibacterial tests. A drop of freshly collected spittle was placed in each of three of four cylinders included in each petri dish; sterile, distilled water, placed in the fourth cylinder, served as a control. The fungi used in these studies were: *Alternaria* sp., *Aspergillus niger* Van Tiegh., *Botrytis cinerea* Pers., *Curvularia* sp., *Cephalothecium roseum* Cda., *Lenzitea trabea* (Pers.) Fries, *Ophiobolus graminis* Sacc., *Penicillium expansum* Link, *Rhizoctonia leguminicola* Gough and Elliott, and *Rhizopus nigricans* Ehr. The following species of bacteria were used in the antibacterial test: *Aerobacter aerogenes* (Krus) Beij., *Agrobacterium tumefaciens* (Smith & Townsend) Conn, *Alcaligenes viscosus* (Weldin & Levine) Weldin, an unidentified bacterium labeled "*Bacillus herbicola* B. & D.", *B. subtilis* (Cohn) Praznowski, *Corynebacterium flaccumfaciens* (Hedges) Dowson, *C. michiganense* (E. Smith) Jensen, *Escherichia coli* (N.) Cast. & Chamb., *Micrococcus pyogenes* var. *aureus* (Rosenbach) Zopf., *M. pyogenes* var. *albus* (Rosenbach) Schr., *Pseudomonas fluorescens* Migula, *Sarcina flava* De Bary, *S. lutea* Schr., *Serratia marcenscens* Bizio and *Xanthomonas phaseoli* (E. Smith) Dowson.

The bacteria occurring in spittle were isolated in pure culture from agar plates that were used in the quantitative bacterial determinations and also from streak plates made from spittle either as collected in the field or diluted with sterile, distilled water.

Cultures were isolated also from the body cavity of meadow spittlebug nymphs. The living insect was imbedded in sterile, low-melting-point histological wax. The wax containing the insect was trimmed to a small block using a sterile razor blade. With the aid of a stereoscopic microscope at 3X magnification thin sections of the block were cut away with a sterile razor blade, until the body cavity of the nymph was opened. A portion of the liquid contents of the body cavity was removed with a sterile, capillary pipette and placed in nutrient broth. These cultures were subsequently plated or streaked upon nutrient agar. An attempt was made to sterilize the surface of the body of nymphs using an ammonium salt, before operations on the body for the purpose of isolating bacteria from the haemoceal. This method was similar to that used by Angus (1952). The solution apparently penetrated into the body cavity and sterilized that area also.

RESULTS

The presence of sugars and amino acids in plant juices and in spittle was determined by paper chromatography. These materials were detected in studies conducted during 1955 and some of them were identified in similar studies in 1956 (figs. 1 and 2).

The chromatograms (figs. 1 and 2) illustrate the complexity of the mixture of sugars and amino acids that are potentially available to satisfy the nutritional requirements of spittlebug nymphs and the bacteria found both in the nymphal digestive tract and in the spittle. Each spot on the chromatograms indicates the presence of one or more compounds; much additional work will be required to identify, with certainty, all of the sugars and amino acids present. Figure 3 is included to show the rates of migration of a number of individual amino acids and not for the purpose of identification.

Hydrolysis of the expressed plant juices, in general, reduced or eliminated those sugars that migrated more slowly than the monosaccharides (fig. 1). This is particularly true with reference to red clover (*Trifolium pratense* L.) and to a lesser degree in the case of alfalfa (*Medicago sativa* L.).

Sucrose and glucose were present in the juice expressed from red pine (*Pinus resinosus* Ait.), but only glucose was present in juice from the Scotch pine (*Pinus sylvestris* L.) Hydrolysis apparently increased the concentration of monosaccharides in the juice of red pine; it also resulted in the appearance of two slowly moving oligosaccharides that were absent in the unhydrolyzed juice of red pine. In the unhydrolyzed juice of Scotch pine only glucose was present, but after hydrolysis five or six monosaccharides were formed. This result probably means that the expressed juice of Scotch pine contained one or

more complex carbohydrates which did not migrate on the chromatograms.

Glucose apparently was present in all of the plant juices both before and after hydrolysis. Unfortunately, in these preliminary studies, the concentration of juices used was too great and this resulted in the incomplete separation of the sugars and consequently left the identification of many of the sugars present in doubt. Free aldopentoses were present in the unhydrolyzed juices of alfalfa and red clover, but were absent in juices of red and Scotch pine.

ently present in spittle from alfalfa (both hydrolyzed and unhydrolyzed) and in hydrolyzed spittle from red pine. The detection of ribose may indicate the presence of ribose nucleic acid. The identity of the other aldopentoses will not be certain until additional work is done.

Hydrolysis of spittle from alfalfa, red pine and Scotch pine increased the number of sugars present as compared with unhydrolyzed spittle. No sugars were found in the hydrolyzed spittle from red clover.

The amino acid composition of the plant juices,

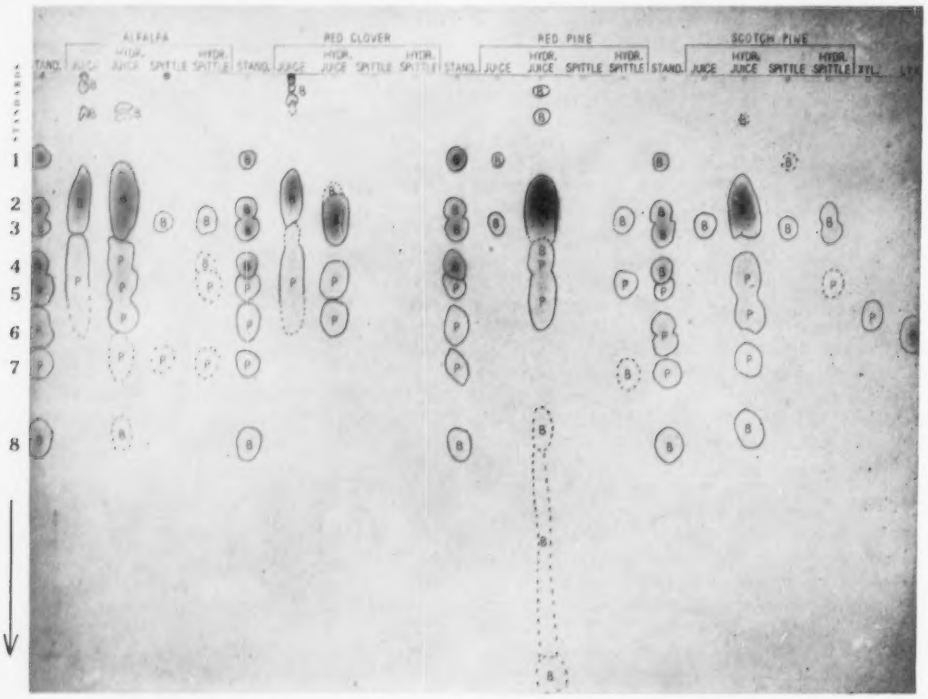


FIG. 1. Sugars. Chromatograms of expressed juices (untreated and hydrolyzed) of four host plants and of cercopid spittle (untreated and hydrolyzed) derived from them. The following standard sugars were used as controls: 1. (Brown)—Sucrose; 2. (Brown)—Galactose; 3. (Brown)—Glucose; 4. (Brown)—Mannose; 5. (Pink)—Arabinose; 6. (Pink)—Xylose—lyxose; 7. (Pink)—Ribose; 8. (Brown)—Rhamnose. The color of spot on the chromatogram produced by the aniline reagent is labeled B (Brown) or P (Pink). Dotted outline of spot indicates only a trace of sugar.

No sugars were found in unhydrolyzed spittle obtained from red clover and red pine. Glucose and a trace of pentose were present in spittle obtained from alfalfa. Glucose and an oligosaccharide were also found in spittle collected from Scotch pine. The presence of rhamnose in the hydrolyzed juice from alfalfa and Scotch pine is reasonably certain, though this sugar was not detected in the unhydrolyzed juice. Of the four aldopentoses, ribose migrates the most rapidly and separates clearly from xylose and lyxose (which were incompletely separated under the conditions of this work). Ribose was apparused in this study, is probably more complex than is indicated by fig. 2. It is evident that the juices of the two legumes contain a larger number of amino acids than the pine juices. Hydrolysis increased the number of detectable amino acids in the pine juices; this probably means that the expressed juices of the pines contained soluble proteins or polypeptides. The number of amino acids was not appreciably increased in hydrolyzed alfalfa juice although a few (one fourth the number found in hydrolyzed juice) of these constituents were detectable in hydrolyzed juice that did not appear in the unhydrolyzed juice. Fewer amino

acids were found in the hydrolyzed juice of red clover; no explanation of this is apparent from the present data.

Fast running amino acids were not found in unhydrolyzed juice of red or Scotch pine; after hydrolysis these acids were present. The slow running amino acids were absent, as well as most of the fast running types, from unhydrolyzed cercopid spittle.

No amino acids were observed in spittle from red clover although after hydrolysis the number of amino acids detectable was approximately the same as found in hydrolyzed spittle from alfalfa. Amino acids were detected in hydrolyzed spittle from red pine although none were apparent before hydrolysis; these results are similar to those obtained with spittle from red clover. Spittle from Scotch pine contained only about one third the number present in the hydrolyzed juice expressed from this plant and hydrolysis of the spittle failed to increase the number of amino acids detected.

Random collections of 23 different spittle masses from various plants gave pH values that ranged from 6.15 to 7.81 with a mean of 7.26 and a median of 7.15. The pH values of the juices of 5 plants and the spittle collected from each were: Red clover (*Trifolium pratense* L.) pH 6.18 (plant), pH 7.05 (spittle); wheat (*Triticum vulgare* Vill.) pH 5.73, pH 7.10; white snakeroot (*Eupatorium rugosum* Houtt.) pH 6.02, pH 7.80; plantain (*Plantago major* L.) pH 5.94, pH 7.38; and wild carrot (*Daucus carota* L.) pH 6.36, pH 7.58.

The numbers of bacteria that occurred in fresh spittle, as determined by the serial dilution plating technique, ranged from 18.4 to 108.4 millions with an average of slightly fewer than 60 millions of bacteria per milliliter of frothy spittle (Table I.). Such large numbers probably influence the physical and chemical nature of the spittle. Table II shows that the numbers of bacteria increase, under laboratory conditions, until the third or fourth day after which there is a decrease in numbers.

Microscopic examination of stained smears of spittle revealed that almost all of the bacteria were Gram negative rods. These rods varied in size and shape from long, slender, slightly curved forms to short plump types; a few vibrios were observed.

Twenty-five bacterial isolates were obtained

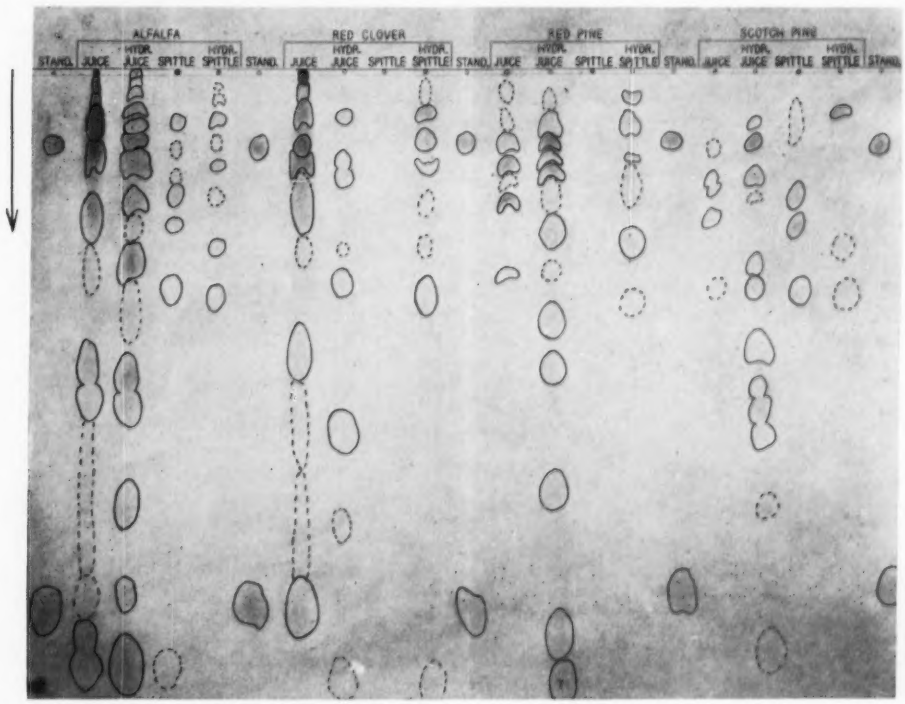


FIG. 2. Amino Acids. Chromatograms of expressed juices (untreated and hydrolyzed) of four host plants and of cercopid spittle (untreated and hydrolyzed) derived from them. Asparagine and phenylalanine were used as standard amino acids. Ninhydrin reagent was used to detect amino acids. Dotted outline of spot indicates only a trace of amino acid. Y = Yellow.

from meadow spittlebug spittle; all were Gram negative rods. Thirteen of the cultures produced white colonies; 10 produced yellow ones; 1 produced a brown colony and 1 produced a purple one. Five of the isolates were non-motile; 2 died before this characteristic was determined. Three of the isolates belong to the genus *Flavobacterium* and 2 belong to the genus *Achromobacter*.

Twenty-three bacterial cultures were isolated from the body cavities of meadow spittlebug nymphs. Fourteen of these isolates produced white colonies; 8 produced yellow ones, and 1 produced a brown colony. Two isolates were Gram positive, spore-forming rods; two were Gram positive spheres and all the others were Gram negative rods. All of the isolates, except 2, were motile. Twenty-one of the bacteria were identified to genus as follows: *Bacillus* (2), *Sarcina* (2), *Xanthomonas* (1), *Agrobacterium* (7), *Achromobacter* (5) and *Flavobacterium* (4).

In the antifungal studies no zone of inhibition was observed in any inoculated agar plates except those inoculated with *Aspergillus niger*. Small clear inhibition zones were present around two of the three cylinders that received spittle. No zones of inhibition occurred in any of the plates seeded with the test bacteria; this indicated the absence of any antibacterial properties present in the spittle.

Spittle possesses little, if any, protective properties against desiccation for the included bacteria. The recovery of viable cells after 3 weeks storage at 28°C was 0.94% of the number of cells originally present (total number at 0 days was 225,773); after 11 weeks the survival was only 0.23% of the original cells. Comparable survival results from a lot stored at 37°C after 3 and 11 weeks storage was 4.20% and 0.0% respectively.

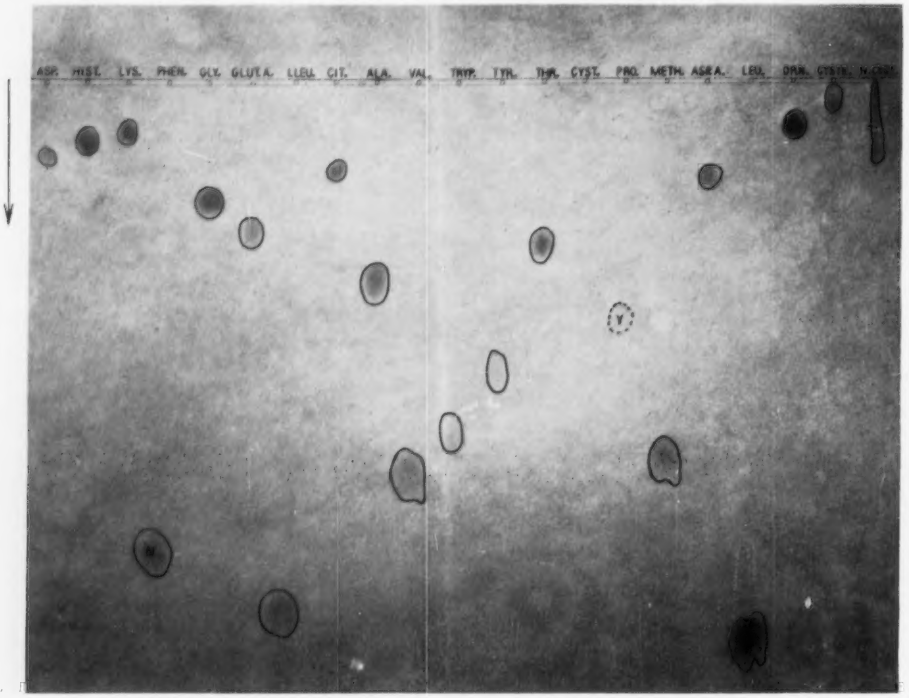


FIG. 3. A chromatogram of single amino acids which illustrates the rate of migration of various amino acids. Ninhydrin was used to detect amino acids. Dotted outline of spot indicates only a trace of amino acid. Bl=Blue spot. Y=Yellow spot. Asp.—Asparagine; Hist.—Hystidine; Lys.—Lysine; Phen.—Phenylalanine; Gly.—Glycine; Glut.—Glutamic acid; I. Leu.—Iso leucine; Cit.—Citruline; Ala.—Alanine; Val.—Valine; Tryp.—Tryptophan; Tyr.—Tyrosine; Thr.—Threonine; Cyst.—Cystine; Pro.—Proline; Meth.—Methionine; Asp. A.—Aspartic acid; Leu.—Leucine; Orn.—Ornithine; Cyste.—Cysteine; H. Cyst.—Homo cystine.

DISCUSSION

One of the objectives of this study was to learn whether spittlebug spittle provided a favorable environment for bacterial growth, particularly phytopathogenic bacteria. All of the results of these studies indicate that conditions are favorable even though only two isolates (*Achro-*

mobacter) were identified as belonging to a genus including plant pathogens.

The pH of the spittle varied from 6.15 to 7.81; the optimum pH level for the growth of most bacteria is included in this range. The pH of plant juices, for most bacterial development, was a little below the optimum required.

TABLE I

NUMBER OF BACTERIA (MILLIONS PER MILLITER) FOUND IN FRESH SPITTLE

SAMPLE NUMBER	NUMBER OF BACTERIA
1	18 4
2	32 5
3	61 2
4	41 3
5	29 6
6	98 8
7	40 6
8	97 2
9	60 4
10[a]	108 4
11[a]	90 4
12[a]	42 4
	Average. 59 4

[a]=Two or more spittle masses mixed together.

TABLE II

NUMBER OF BACTERIA (MILLIONS PER MILLITER) IN SPITTLE AFTER INCUBATION OF THE SPITTLE AT 28°C.

DAYS OF INCUBATION	SPITTLE MASS				
	1[a]	2[a]	3[b]	4[b]	5[b]
0	2 7	4 0	108 4	90 4	42 4
2	15 5	6 2	137 4	224 6	75 8
3	92 6	54 7	30 7	136 8	97 0
5	41 6	48 5			
6			227 6	186 0	92 4

[a]Spittle diluted 1: 2 with sterile distilled water.
[b]Spittle included more than 1 mass. Escape of some of the air bubbles permitted the use of bubble-free spittle, consequently the actual liquid volume was greater.

Both pathogenic and saprophytic bacteria are capable of utilizing various sugars and amino acids for some of their nutritional requirements. Since these constituents are present in spittle, it furnishes a satisfactory nutritional environment for many species. This was demonstrated by the numerical increase of bacteria in spittle during various periods of incubation.

The similarity between the bacterial isolates from spittle and nymphal bodies is apparent. The number of isolates from each was 25 and 23 respectively of which 13 isolates from spittle and 14 from the body cavities produced white colonies. Yellow colonies were produced by 10 and 8 isolates respectively and one brown colony was produced from each source. Most of the isolates were motile Gram negative rods. Some of the bacteria from both sources were identified as belonging to the genera *Achromobacter* and *Flavobacterium*. These similarities indicate that most of the bacteria in spittle probably are not contaminants from the air or the plants, but are introduced into the spittle from the bodies of the nymphs.

The spittlebug nymph has available, for its nutrition, the complex mixture of metabolites elaborated by the host plant. This preliminary study pertaining to the presence of sugars and amino acids in spittle and in plant juices shows that complex mixtures of these constituents are contained in the spittle. It is apparent that the nutritional relationships between spittlebug nymphs, the bacteria present in the nymphal body and in spittle are also complex.

If the sugars and amino acids in plant juices are the utilizable sources of carbon and nitrogen it would be expected that the composition of plant juices would be simplified as the spittlebugs and their associated bacteria obtain their nutrients from these materials. This supposition was demonstrated to be true because each of the four types of spittle masses examined contained fewer sugars and amino acids than the plant juices from which each was derived. This diminution is particularly noticeable for the sugars. Two of the spittle samples gave no positive tests for the presence of sugars (Plate I). In the two other samples of spittle some glucose was detected. A similar situation resulted from the tests with amino acids. Two samples of spittle (from red clover and red pine) were devoid of amino acids, while the number of amino acids detected in spittle from alfalfa and Scotch pine was about one half that found in the corresponding plant juices. It is noteworthy that the fast running amino acids in these two juices (alfalfa and Scotch pine) were essentially removed by the combined action of the nymphs and the bacteria in their bodies.

The formation of stable bubbles in an aqueous solution depends upon the presence of a suitable surface tension depressant. It is extremely difficult to free spittle from bubbles. It is possible that the surface tension depressant for bubble stability in spittle is contained in the plant juices (saponins etc.). However, it is also possible that the bacteria present in spittle synthesize polysaccharides that stabilize the bubbles formed. In experiments on the production of polysaccharides by a species of the genus *Xanthomonas* in aerated liquid media great difficulties were encountered in controlling foaming (Lilly *et al.*). It is probable that three out of the four samples of spittle analyzed contained polysaccharides; this was shown by the

increase in the number of sugars detected in hydrolyzed spittle.

SUMMARY

The microbiology of cercopid spittle and of the body fluids of the meadow spittlebug nymphs was studied; spittle provides a favorable environment for many species of bacteria.

Hydrogen ion concentrations of the juices of five plants and of the spittle collected from each was determined. Spittle was slightly more alkaline than the plant juices; the pH ranged from 7.05 to 7.81. The pH of the juices of the plants, from which the spittle was collected, ranged from 5.73 to 6.36.

Antifungal and antibacterial potency of spittle and the included bacteria was tested against 13 species of fungi and 15 species of bacteria. No zones of inhibition occurred in the bacterial tests. Limited zones of inhibition were found on only one of the fungi tested.

The presence of certain sugars and amino acids in spittle and plant juices was demonstrated by paper chromatography. There are fewer sugars and amino acids present in spittle than in the plant juice from which the spittle is derived. This demonstrates the simplification of the composition of plant juices as the spittlebug nymphs and their associated bacteria obtain their nutrients from these materials.

REFERENCES CITED

Angus, T. A. 1952. The aerobic bacteria associated with the eastern hemlock looper *Lamdina fiscellaria* (Gn.). Canadian Jour. Zool. 30: 208–12.

Cecil, Rodney. 1930. The alimentary canal of *P. leucophthalmus* L. Ohio Jour. Sci. 30: 125–7.

Chandler, S. C. 1953. Life history and control of pecan spittlebug. Jour. Econ. Ent. 40: 450–4.

Claton, R. A., and **F. M. Strong.** 1954. New solvent system for the separation of amino acids by paper chromatography. Analyt. Chem. 26: 1362–3.

Ewart, W. H., and **R. L. Metcalf.** 1956. Preliminary studies of sugars and amino acids in the honeydews of five species of coccids feeding on citrus in California. Ann. Ent. Soc. America 49: 443–7.

Gray, Reed A. 1952. Composition of honeydew excreted by pineapple mealybugs. Science 115: 129–33.

Gruenhagen, R. H., A. J. Riker, and **C. A. Richards.** 1947. Burn blight of jack and red pine following spittle insect attack. Phytopath. 37: 757–72.

Gruner, Max. 1900. Beiträge zur Frage des Aftersekretes der Schaumcikaden. Zool. Anz. 23: 431–6.

Guilbeau, B. H. 1908. The origin and formation of the froth in spittle insects. Amer. Nat. 42: 783–9.

Kershaw, J. C. 1914. The alimentary canal of a cercopid. Psyche 21: 65–72.

Kurasawa, H., S. Saito, and **M. Honma.** 1952. Studies on the metabolism of carbohydrates. Part 3. A study on the paper chromatography of sugar. On spraying units. Bull. Faculty, Niigata Univ. 3: 47–52.

Leach, J. G., V. G. Lilly, H. A. Wilson, and **M. R. Purvis, Jr.** 1956. Bacterial polysaccharides; the nature and functions of the exudate produced by *Xanthomonas phaseoli*. Phytopath. (In Press).

Licent, Emile. 1912. Recherches d'anatomie et de physiologie comparées sur le tube digestif des Homoptères supérieurs. La Cellule 28:: 1–161.

Lilly, V. G., H. A. Wilson, and **J. G. Leach.** Bacterial polysaccharides. 2. laboratory scale production of polysaccharides by *Xanthomonas* species (unpublished).

Mundinger, F. G. 1946. The control of spittle insects in strawberry plantings. Jour. Econ. Ent. 39: 299–305.

Osborn, Herbert. 1916. Studies of the life histories of froghoppers in Maine. Maine Agric. Expt. Sta. Bull. 254: 265–88.

Partridge, S. M. 1948. Filter paper partition chromatography of sugars. 1. General description and application to the qualitative analysis of sugars in apple juice, egg whites and foetal blood of sheep. Biochem. Jour. 42: 238–48.

Putnam, W. L. 1939. The plum nursery mite, *Phyllocoptes fockeui* Nal. and Trt., Rept. Ent. Soc. Ontario 70: 38.

Sanderson, Roger F. 1947. Saratoga spittlebug injury to pine. Jour. Econ. Ent. 40: 26–33.

Secrest, H. C. 1944. Damage to red pine and jack pine in the Lake States by the Saratoga spittlebug. Jour. Econ. Ent. 37(3): 447–8.

Severin, H. H. P. 1947. Transmission of virus of Pierce's disease of grapevines by spittlebugs. Phytopath. 37: 364.

1950. Spittle insect vectors of Pierce's disease virus. II. Life history and virus transmission. Hilgardia 19: 357–82.

Sulc, Karel. 1911. Respiration, Tracheensystem und Schaumprodukition der Schaumcikaden-larven. (Aphrophorinae-Homoptera) Zeits Wiss. Zool. 99: 147–88.

Weaver, C. R., and **J. W. Hibbs.** 1952. Effect of spittlebug infestation on nutritive value of alfalfa and red clover. Jour. Econ. Ent. 45: 626–8.

Weaver, C. R., and **D. R. King.** 1954. Meadow spittlebug. Ohio Agric. Expt. Sta. Res. Bull. 741.

Weber, H. 1930. Biologie der Hemipteren. Springer: Berlin.

Wise, C. S., R. J. Dimler, H. A. Davis, and **C. E. Rist.** 1955. Determination of easily hydrolyzable fructose units in dextran preparations. Analyt. Chem. 27: 33–36.

DIPTERA: CULICIDAE. INSECTS OF MICRONESIA, by RICHARD M. BOHART. Vol. 12, no. 1, pp. 1–85. 1956 [Jan. 21, 1957]. Illus. Bernice P. Bishop Museum, Honolulu, Hawaii. Price $1.75.

The 47 species or subspecies of mosquitoes found in Micronesia are listed by island group, keys are presented to separate the taxa and each of the latter is described. The author points out the high degree of endemicity, 28 of the species being found only in Micronesia, and 22 of them endemic to particular island groups. Of considerable insterest is the fact that there is a strong Oriental influence in the fauna, and the relationship with the Australian fauna is particularly weak. Thirteen new species are described and there are many original illustrations, of both the new species and those previously described. This is a very valuable addition to our knowledge of the mosquitoes of the world.

ALAN STONE,
Entomology Research Division,
U. S. Department of Agriculture.

AN INVESTIGATION OF THE TAXONOMIC VALUE OF THE PHALLUS IN THE LYGAEIDAE[1] (HEMIPTERA-HETEROPTERA)

PETER D. ASHLOCK
University of California, Berkeley

The foundation of the higher classification of the hemipterous family Lygaeidae was laid down by Stål (1862, 1872, 1874). Modifications and additions have been made by Reuter (1878), Breddin (1907), Barber (1917, 1918) and Barber and Bruner (1933). Since the time of Stål, there has been no review of the higher categories of the family as a whole, nor has there been any attempt to analyze any character complex not normally used to test the validity of these groups.

It is hoped that this work, together with the work of Slater and Hurlbutt (1957) on the metathoracic wings, and surveys of other character complexes will permit detailed analysis of the relative taxonomic importance of characters used in the higher group taxa within the family, and will permit a sounder basis for the understanding of the relationships of these groups. That the phallus sometimes provides characters useful in higher category distinction has been shown by such works as those of Singh-Pruthi (1925), Kullenberg (1947), Leston (1955 *et al.*).

A secondary consideration was the hope that this study would establish characters for specific discrimination. This hope has been fulfilled in some cases, but, unfortunately, not to the degree originally anticipated. Furthermore, the difficulty encountered in the inflation of the phallus will make routine discrimination impractical, although the organ may, of necessity, need to be used in certain critical cases. In some species with heavily sclerotized parts, the phallus may readily be utilized for specific purposes as these forms may be observed without laborious erection procedures.

HISTORICAL REVIEW

A lengthy review of the work pertaining to heteropterous male genitalia is felt to be unnecessary, since it has been thoroughly done by Dupuis (1955) as discussed below. The few works concerned directly with the Lygaeidae will be briefly reviewed.

By far the most basic work concerned with the male genitalia of Hemiptera is that of Singh-Pruthi (1925). This paper is the first attempt to analyze in detail the structures of the male genitalia of Hemiptera, and this analysis is the foundation on which further work must be based. In his review of the male genital structures of the order, Singh-Pruthi described the phallus of fourteen species of Lygaeidae. Throughout his study, the phallus was not inflated, so that many of the conclusions reached concerning the interrelationships of species are based upon inadequate evidence. He also incorrectly, but understandably, characterized the phallus of the Lygaeidae by "the total absence of conjunctival appendages, and . . . the extreme elongation and fineness of the vesica." (p. 161).

Ludwig (1926) thoroughly investigated the morphology of the male and female genitalia of *Lygaeus equestris* (L.) and compared them with the genitalia of the pyrrhocorid, *Pyrrhocoris apterus* (L.). This work is fundamental for an understanding of genital structure and function.

Piotrowski (1950) surveyed the male genitalia of a number of families of Heteroptera, and included six species of Lygaeidae. As with the work of Singh-Pruthi, the phallus was uninflated, so that his study is of limited value here.

The most recent work on the genitalia of the Lygaeidae is that of Bonhag and Wick (1953). The morphology of the male and female genitalia of *Oncopeltus fasciatus* (Dallas) was thoroughly investigated. Analysis of function is particularly good and some errors made by Ludwig (1926) are corrected.

A particularly useful and complete review of the male and female genitalia of the Heteroptera has been presented by Dupuis (1955). It contains detailed descriptions of the generalized condition, a critically annotated bibliography of papers concerned with the subject, and a critical glossary of terms. Terms accepted by Dupuis have been used for the most part herein, since they are the result of the latest review of the subject. Little attempt has been made to criticize Dupuis' morphological conclusions or his choice of terms because the present work is primarily taxonomic in nature and does not attempt morphological conclusions.

MORPHOLOGY OF THE MALE GENITALIA OF LYGAEIDAE

The Pygophore and Associated Abdominal Segments

Abdominal segments eight through eleven are all associated with or are a part of the male genitalia, and are normally retracted within the seventh segment when the insect is not in copulation. The eighth segment in the Lygaeidae is simple and consists of an undifferentiated ring which sometimes narrows dorsally. Tergal and sternal

[1]A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at the University of Connecticut. Accepted for publication December 17, 1956.

regions are not differentiated and spiracles are absent.

The ***pygophore***, or genital capsule, is derived from the ninth abdominal segment and carries the remaining segments, as well as the parameres and phallus. It is cup-shaped, with the opening located dorsally. Its anterior boundary is always complete dorsally in the Lygaeidae, although frequently reduced to a narrow bridge. The posterior margin is either rounded or ridged horizontally, but never prolonged into processes such as are found in many other families of Heteroptera. The posterior ventral surface may have one or two foveae present, which may prove to be of some taxonomic importance, particularly in the Lygaeinae.

The dorsal opening of the pygophore is normally covered by the ***proctiger*** which bears the anus and the remaining abdominal segments. A small tergite, called tergum IX by Bonhag and Wick (1953) and located dorsally next to the pygophore, seems to be present only in the Lygaeinae, apparently being fused with the pygophore or lost entirely in all other members of the family. Segments ten and eleven surround the anus and may be complete rings or divided into tergal and sternal regions. The proctiger folds down into the genital atrium when the phallus is erected.

Within its posterior margin, the pygophore is greatly modified where there is contact with the parameres (see discussion under *Parameres*) and varies greatly from group to group. The area would be impractical to analyze taxonomically because of the difficulty of interpreting its appearance. Furthermore, its variation is probably a reflection of the variation in the parameres.

From the floor of the pygophore the suspensory apodemes (***apodèmes suspenseurs***, Dupuis, 1955) rise like arms of a tuning fork and connect with the stapes of the phallus. The two structures together form the articulatory apparatus and permit the phallus to swing outward from the genital atrium.

Parameres

The claspers of the Heteroptera were interpreted as styli by Marks (1951), following Michener (1944), and by Bonhag and Wick (1953). Singh-Pruthi (1925) and Dupuis (1955) concluded that these structures are phallic organs or ***parameres***, and this interpretation is followed here.

In the Lygaeidae, the parameres are paired, symmetrical structures[2] originating on the membrane between the pygophore and the phallus. The basal part of the paramere, where it is continuous with the membrane, has been termed the ***basis parameri*** (Dupuis, 1955) and is frequently prolonged laterally, probably to afford a more efficient pivot mechanism with the pygophore. In the Lygaeidae, the parameres are usually divisible into two regions, a basal "shank" and an apical, usually flattened and curved "blade". Both may have variously shaped processes or hollowed-out areas on them. The shank in particular often has processes at its distal end before the base of the blade. The surface of the paramere may also have hairs or small tubercules, distributed generally or in patches, which are probably of sensory function. The inner curve of the blade is often furnished with minute teeth that can be seen only under high magnification.

In use, the parameres are extended out from the pygophore and grasp the ovipositor of the female. When they are withdrawn, they lie deep within the pygophore with only the outer surface of the blades visible, and because of the processes on the shank and the modified surfaces of the pygophore they remain in a fixed position.

Little taxonomic use has been made of the parameres in the Lygaeidae, other than figuring them incidental to a new species description, or more rarely, in generic revisions. Slater (1955), however, made extensive use of them in his revision of the Pachygronthinae of the world, and found them useful to separate species into groups. He states, however, that they "have been on the whole, rather disappointing characters in this subfamily." Investigation of a few groups with a view to their use in discriminating species has shown that they are of no value at all in some groups and of considerable value in others. In most cases, the view that shows the best characters is a dorsal, or inner one, oriented to show the flat surface of the blade. The shape and position of the blade, shank processes, and ***basis parameri*** all provide good characters, the first two, perhaps, having the most value.

Incidental to the work on the phallus, it was found that many groups within the family have specific paramere patterns. A few examples are worth noting. Many of the Orsillini have parameres in which the shank is perpendicular to the flat surface of the blade. The Lygaeinae, on the other hand, have the shank nearly perpendicular to the narrow edge of the blade, and in addition, the blade may distally curve upward and basally have a hollowed-out area on the lower edge. In most groups, the blade makes a greater angle with the shank, and it curves like a sickle. The Lethaeini (*s. str.*, not *Drymus* and its allies) have parameres which are characterized by a short, stout shank and a stout, triangular blade. It is felt that a comparative study of the parameres would be quite rewarding, not only as an aid to species discrimination, but also as an aid to understanding generic relationships and to a lesser extent, those of the higher categories.

[2]Dupuis (1955, p. 203) listed the Lygaeidae with those families of Heteroptera that have asymmetrical parameres. However, in correspondence with J. A. Slater, he said that his information was from a literature reference and that he had not checked the point himself.

Phallus

Singh-Pruthi (1925) considered the heteropterous phallus, or intromittent organ, to be divisible into two main regions, a proximal one, the phallotheca, and a distal one, the endosoma (Fig. 8). He also found that the organization of the phallus separated members of the suborder into two groups. These groups in general are equivalent to the Pentatomorpha and Cimicomorpha of Leston, Pendergrast and Southwood (1954). The pentatomorph phallus (of which the lygaeid phallus is an example) is characterized by having the endosoma differentiated into two morphologically distinguishable areas, a proximal conjunctiva and a distal vesica (Fig. 8). The cimicomorph phallus is not so divisible. In the Lygaeidae the phallotheca, conjunctiva and vesica all may bear processes of various types which are collectively termed ***processus phallothecae***, ***p. conjunctivae*** and ***p. vesicae***, and in addition, various sclerites which may be termed the ***sclerite phallothecae***, etc.

The ***ductus seminis*** (the ejaculatory duct plus the endophallus) runs completely through the lumen of the phallus and is divided into vesical and conjunctival components, which may be ascertained by the position of a complex structure, the ejaculatory reservoir, which lies at the base of the vesica.

Phallotheca.—The phallotheca is essentially cup-shaped and is that part into which the endosoma is invaginated when the phallus is deflated and not in use. The base of the phallotheca is formed by the basal apparatus (Fig. 19).[3] The stapes (Fig. 19) is the most apparent part of the basal apparatus and is horseshoe-shaped with a dorsal transverse connection, the ***ponticulus basalaris***. The lower surface serves as the point of insertion of the remotor muscles of the phallus. The dorso-lateral areas are modified to receive the suspensory apodemes and form the phallic pivot. Just above the pivot are a pair of mushroom-shaped processes, the ***processus capitati***, which serve as the point of insertion of the promotor muscles of the phallus. The ***ductifer***[4] (Fig. 19) lies along the dorso-ventral mid-line of the basal apparatus and serves as the point of entry of the duct leading to the lumen of the phallus. Ventrally the ductifer projects for a short distance into the lumen and is partially divided in order to provide a basal support for the seminal duct.

The remainder of the phallotheca is usually in the form of a short, sclerotized tube and is in most cases connected with the stapes by a membrane. The pigmentation of the phallotheca is frequently not uniform and may become localized to form sclerite-like areas. The only processes found on the phallotheca of lygaeids are paired sclerotized lobes (Fig. 7) located dorso-laterally on the distal margin. These processes are found in some groups of Lygaeidae, and were termed "parameres" by Bonhag and Wick (1953).

Conjunctiva.—In the Lygaeidae, the conjunctiva is tubular and more or less elongate. It is delimited distally by a fold,[5] located at the base of the ejaculatory reservoir, that occurs as a result of its being withdrawn into the phallotheca. The fold disappears upon complete inflation, but then the base of the ejaculatory reservoir delimits the area. Processes, if present, are not usually numerous and are most frequently in the form of relatively small inflatable lobes (Fig. 19). Most often these lobes occur as a subdistal lateral pair and as a single, dorsal, distally located lobe. In some Myodochini, the conjunctiva may bear from two to many spines (Figs. 21–23) either set directly upon the conjunctiva or on inflatable lobes, and in addition, there may be sclerotized plates or rods present. Ring sclerites on the conjunctiva have been found only in the Orsillini, and are located a short distance before the distal end of the region.

Ductus Seminis.—The seminal duct is a thin tube that passes through the lumen of the phallus and terminates at the secondary gonopore (Figs. 9, 12). It is divided into conjunctival and vesical components by the ejaculatory reservoir. The ***ductus seminis conjunctivae*** is always narrow, flexible, and lightly pigmented, while the ***ductus seminis visicae*** is usually thicker, less flexible, and is often darkly pigmented. The walls of both components of the duct are made up of what appear to be very fine, thickened annulations, but what is actually a close spiral, quite similar to the taenidia that make up the wall of insect tracheae. The distal end of the vesical seminal duct frequently becomes free of the inflatable parts of the phallus and it then is termed the ***processus gonopori*** (Figs. 13, 14). It is usually coiled, and varies greatly in length. The distal opening of the seminal duct is the secondary gonopore, and may be simple in nature or more or less flared. Some of the Lygaeini possess a process, occasionally quite elongate, which continues beyond the secondary gonopore. Any such process which extends beyond the secondary gonopore is herein termed the ***processus apicalis*** or apical process.

[3] *Appareil basal*, Dupuis, 1955. This term was omitted from its alphabetical position in the lexicon, but it is referred to a number of times in the definitions of its component parts.

[4] The term *ductifer* (Bonhag and Wick, 1953) was omitted from Dupuis' (1955) lexicon. It refers to the same structure that Singh-Pruthi (1925) named the basal plates bridge. Dupuis incorrectly synonymized Singh-Pruthi's term with *ponticulus basalaris*, apparently having confused the two structures. Bonhag and Wick's term is quite satisfactory and is adopted here to avoid confusion.

[5] Bonhag and Wick (1953) used the ring sclerite of the vesica in *Oncopeltus fasciatus* (Dallas) to delimit the distal boundary of the conjuctiva rather than the ejaculatory reservoir as orginally employed by Singh-Pruthi (1925). The division proposed by Bonhag and Wick is not practical in those lygaeids that lack the vesical ring sclerite and is impossible in some families, such as the Pentatomidae, which have a very simple vesica.

Ejaculatory Reservoir.—The ejaculatory reservoir is a complex structure located within the proximal end of the vesica, permanently fixed to its dorsal wall. The various parts of this structure were termed the neck, body and wings (Fig. 4) by Bonhag and Wick (1953). The neck is the enlarged basal portion of the vesical seminal duct into which the conjunctival seminal duct enters. The body is usually an enlarged, bowl-shaped structure attached to the dorsal surface of the neck. The wings are paired, flattened processes originating on the dorsal surface of the body. All of these structures may undergo fusion or reduction and in one case (*Clerada apicicornis*) are missing.

Vesica.—The vesica, or distal area of the phallus, is delimited basally by the fold of the conjunctiva and includes the ejaculatory reservoir. Except in the Pachygronthinae and Heterogastrinae, where it is extremely reduced, this division of the phallus is always inflatable, at least basally, and may possess variously placed sclerites and processes. Vesical processes are either inflatable lobes (Fig. 20) usually much longer and more numerous than those on the conjunctiva, and occasionally entirely or basally pigmented, or of a special type, here termed the helicoid process (Figs. 6, 13, 19). This process is a lateral, plate-like extension of the vesica in the form of a short helix or spiral. When the phallus is deflated the helix closes up and forms a cup into which the gonoporal process is coiled, and covers the distal opening of the phallotheca. The inflatable part of the vesica may end with the secondary gonopore, or at the base of the gonoporal process, which structure is discussed with the *ductus seminis*. When the phallus is fully inflated, the vesica generally makes a sharp bend ventrally so that inflatable lobes, if present, are appressed to the conjunctiva.

Mechanical Considerations.—When the phallus is completely retracted, the vesical seminal duct lies loosely coiled on the floor of the phallotheca, and the ejaculatory reservoir is in contact with the basal apparatus. The conjunctiva is inverted entirely within the phallotheca. The vesica extends straight out from the floor of the phallotheca. It is usually tightly twisted, and thereby shortened, so it may also be withdrawn into the phallotheca.

During copulation, the phallus is inserted into the "L" shaped ovipositor of the female. Dissection of specimens killed in boiling water shows that the conjunctiva is limited to the apical half of the ovipositor while the vesica enters both the basal half of the ovipositor and the genital chamber. The various lobes, swellings and the bend at the base of the vesica hold the phallus firmly in place. The gonoporal process enters the spermatheca on the dorsum of the genital chamber for a considerable part of its length, even in species with especially long terminal coils.

Oedancala dorsalis is an important exception to this pattern. In all probability investigation of the other members of the Pachygronthinae, and the Heterogastrinae too, will show them to conform with this species. Here the greatly elongated conjunctiva was seen to pass completely through the ovipositor so that the swellings at the distal end were well within the genital chamber. Thus the conjunctiva of this species is functionally different from that of the majority of the Lygaeidae.

In connection with the function of the conjunctiva, it might be well to mention a short paper by Leston (1955) on the function of the conjunctiva in the Pentatomidae. In this family the region is never tubular as it is in the Lygaeidae, and consists primarily of large, lateral lobes. Leston reports that these lateral lobes press outward, thus holding the phallus in place. The ovipositor blades of Pentatomidae are quite reduced, thereby eliminating the need for the elongate conjunctiva of lygaeids and permitting this region to take over the anchoring functions that are primarily the function of the vesica in the Lygaeidae. Thus it would appear that the function of the conjunctiva, in most cases, is directly related to the degree of reduction of the ovipositor blades.

MATERIALS AND METHODS

Tools for dissection included two pairs of Dumont watchmaker's forceps, size 3C, and a bent *minute nadel* set into the end of a small dowel. Observations were made with a stereoscopic microscope and figures were drawn with the aid of an ocular grid at 54X. The figures are views of the right surface of the phallus unless otherwise indicated, and the dorsal surface of the phallus is always to the right. The figures are to the same scale, with the exception of those of *Artheneis foveolata* Spinola, *Pamphantus elegantulus* Stål, the two orsilline ejaculatory reservoirs, and *Epipolops* sp. which are drawn at twice the

EXPLANATION OF PLATE I

FIG. 1. Ejaculatory reservoir of *Orsillus depressus* Dallas, dorsal view.

FIG. 2. Phallus of *Orsillus depressus* Dallas.

FIG. 3. Ejaculatory reservoir of *Nysius californicus* Stål, dorsal view.

FIG. 4. Ejaculatory reservoir and vesical seminal duct of *Epipolops* sp., dorsal view.

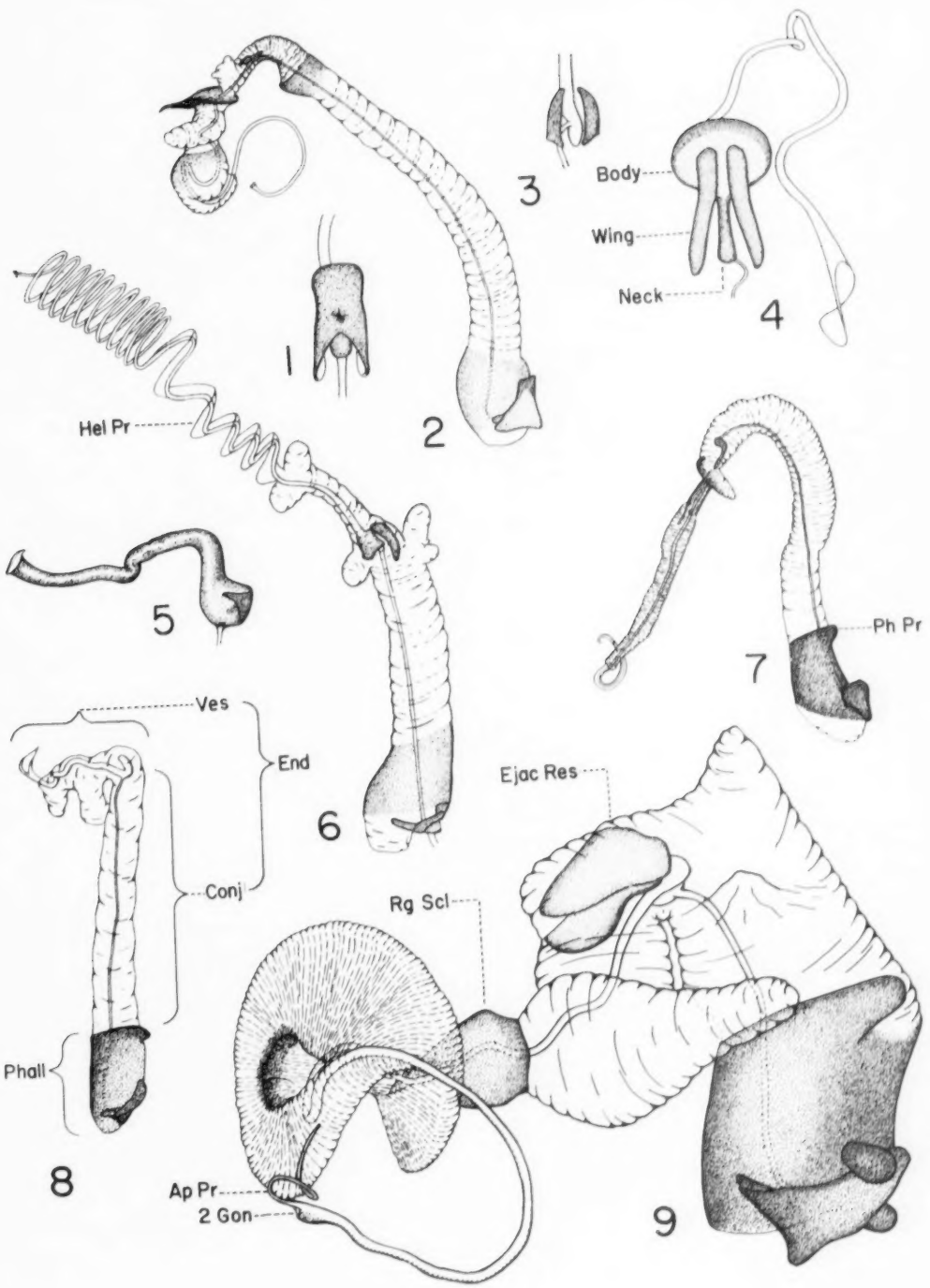
FIG. 5. Ejaculatory reservoir and vesical seminal duct of a new genus near *Ninus*.

FIG. 6. Phallus of *Kleidocerys franciscanus* (Stål). *Hel Pr*, helicoid process.

FIG. 7. Phallus of *Oxycarenus hyalinipennis* (Costa). *Ph Pr*, phallothecal process.

FIG. 8. Phallus of *Cymus angustatus* Stål. *Conj*, conjunctiva; *End*, endosoma; *Phall*, phallotheca; *Ves*, vesica.

FIG. 9. Phallus of *Oncopeltus fasciatus* (Dallas). *Ap Pr*, apical process; *Rg Scl*, ring sclerite; *2 Gon*, secondary gonopore.


1
2
3
Body
Wing
Neck
4
Hel Pr
5
6
7
Ph Pr
Ves
End
Conj
Phall
8
Ejac Res
Rg Scl
Ap Pr
2 Gon
9

usual scale, and *Zeridoneus costalis* (Van Duzee) which is slightly reduced.

Inflation of the Phallus

Because of the great difficulty encountered in the inflation of the phallus, it is felt that rather detailed instructions for this operation are warranted.

Two workable methods of inflating the phallus have been found. The first, which produces the best results, is that used by Leston (1955). A copulating pair is plunged into boiling water. The capsule may then be easily removed from the male and the phallus freed from the female by separating the ovipositor blades longitudinally. This is accomplished by grasping the lateral edges of the seventh or eighth abdominal segment of the female with fine forceps and gently pulling them apart. In species with a long, coiled gonoporal process, this structure may become caught in the spermatheca. Sometimes a gentle pulling will free it, but if not, an understanding of this area must be obtained from additional specimens.

Because of the obvious difficulty of acquiring living material in all cases, a method involving osmotic pressure was also used. The results are often as good as those obtained by natural inflation, but the method can be, to say the least, discouraging. As many as fifteen or more attempts have been made on a single species before a successful inflation was obtained, and with some species, the method was given up as unsuccessful. Even when a degree of inflation occurs, it is often difficult to obtain enough pressure to cause the vesica to make its ventral bend.

The osmotic method of inflation is essentially as follows. The pygophore, or capsule, is removed from the male (which may be softened with ethyl acetate, if necessary) and soaked for fifteen or twenty minutes in a well of a spot plate containing distilled water in which a pellet of potassium hydroxide has been dissolved. It is helpful to crack the capsule with a pair of forceps so that trapped air may be released, and so that the solution can reach internal areas. Removal of small pieces of the capsule is also helpful. When the muscle tissue is cleared, and the silvery appearance, due to air trapped in the phallus, is gone, the latter may be more fully exposed by removing, while still in the solution, most of the remaining capsule and any membranes present. Great care must be taken not to puncture the phallus or tear its membranes, which is quite easily done if the phallus is separated from its articulations. The phallus is then transferred to distilled water and allowed to inflate as much as possible.

Most often the phallus will not inflate completely, or will fail to inflate at all. When it does inflate, this sometimes occurs rapidly, at other times so slowly that it is barely perceptible. In any case, it is always best to allow inflation to proceed as far as possible before attempting other measures. Unnecessary manipulation of the phallus is best avoided.

If the process stops before the phallus is completely inflated, a manipulation involving changing osmotic pressure will avoid actual handling. The phallus should be transferred to the caustic solution until it deflates and then returned to the distilled water, and allowed to inflate as far as possible. This transfer should be repeated until inflation is complete, or until no further inflation takes place. It is important to change the distilled water frequently to eliminate the carry-over of the caustic.

Frequently, the conjunctiva refuses to free itself from the phallotheca. This situation may be overcome by very gently forcing or pulling the vesica from its usual position. Two ways have been found to accomplish this, both of which are better attempted in the caustic solution. The first method is to squeeze the phallotheca gently just above the basal apparatus and below the ejaculatory reservoir, which lie in close approximation, with fine forceps until the ejaculatory reservoir is forced slightly outward. Following this, attempt inflation by returning to distilled water. The other method is possible only where the gonoporal process is sufficiently heavy to be grasped with the forceps. The basal end of the phallus should be held by any remaining parts of the capsule, or by the phallotheca. A gentle puli on the gonoporal process will free the conjunctiva. Again, attempt to stimulate inflation by returning to distilled water.

Although it is usually best to avoid manipulation of the phallus when it is turgid, a partially expanded conjunctiva may often be more fully inflated by squeezing it gently with the forceps. When it is released, it frequently will not reinflate completely. Deflating and reinflating as above will usually result in an again fully turgid phallus.

A beginner at inflating the phallus by this process will probably wish to practice on a large, common species before attempting more valuable specimens. From this standpoint, the members of the tribe Lygaeini may seem to be attractive, but the author found them to be difficult because the membranes of their phalli are particularly

EXPLANATION OF PLATE II

FIG. 10. Phallus of *Artheneis foveolata* Spinola.

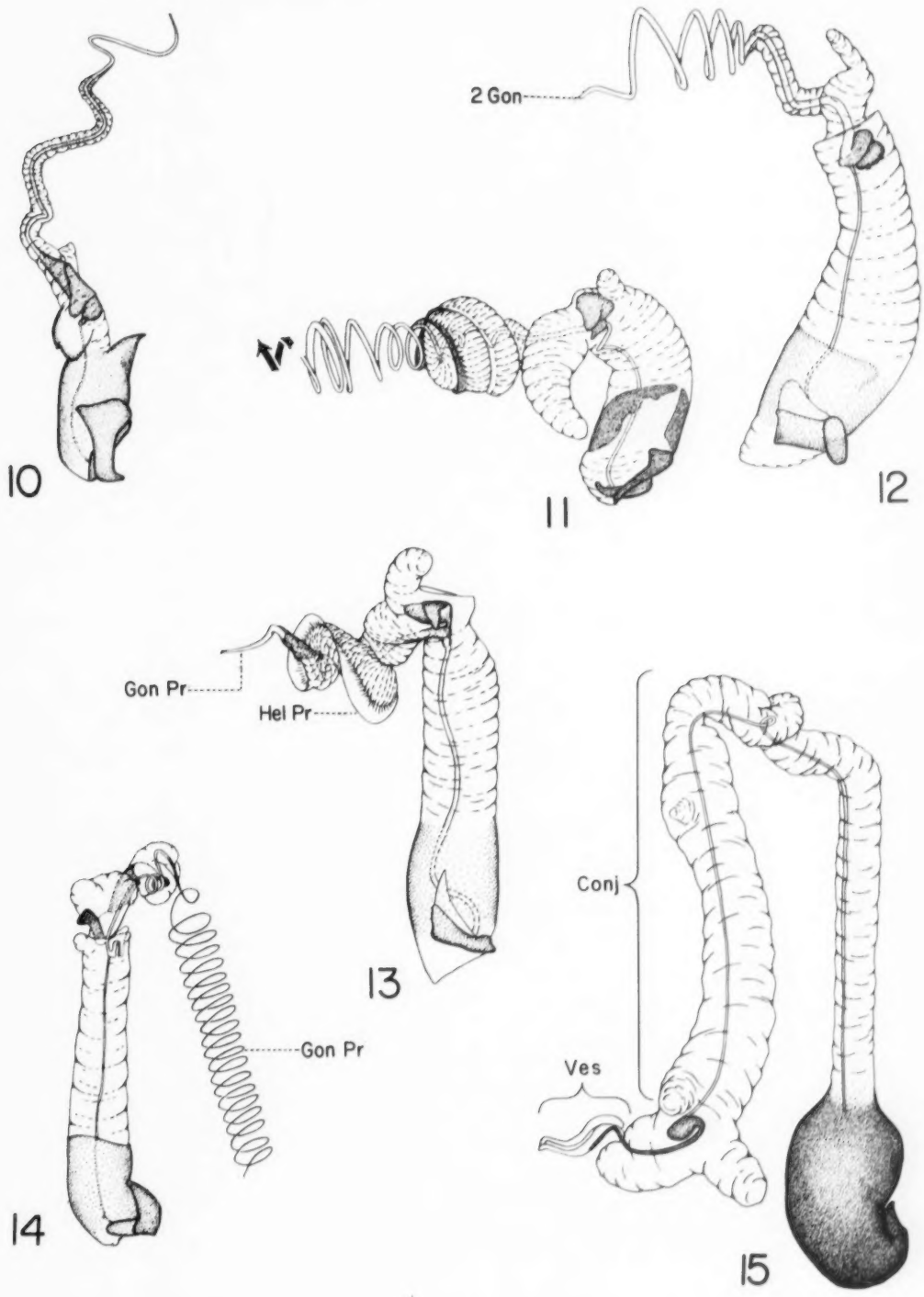
FIG. 11. Phallus of *Hypogeocoris piceus* (Say).

FIG. 12. Phallus of *Pamphantus elegantulus* Stål. *2 Gon*, secondary gonopore.

FIG. 13. Phallus of *Henestaris laticeps* (Curtis). *Gon Pr*, gonoporal process; *Hel Pr*, helicoid process.

FIG. 14. Phallus of *Blissus leucopterus* (Say). *Gon Pr*, gonoporal process.

FIG. 15. Phallus of *Oedancala dorsalis* (Say). *Conj*, conjunctiva; *Ves*, vesica.


2 Gon
Vr
Gon Pr
Hel Pr
Gon Pr
Conj
Ves
10
11
12
13
14
15

delicate. Probably, the least difficulty was encountered while working with representatives of such genera as *Myodocha*, *Beosus* and *Drymus*, and it is suggested that a large rhyparochromine be selected for practice.

The phallus and other genital parts should be rinsed in dilute acetic acid and placed in a genitalia vial with a small drop of glycerine. The glycerine may be rinsed out of the vial with alcohol if further study is necessary.

TAXONOMIC INDICATIONS OF THE LYGAEID PHALLUS

Subfamily **Lygaeinae** Stål 1862

This large subfamily is at present composed of four tribes. The Lygaeini and Orsillini are world wide in distribution, and contain a large number of genera. The remaining two tribes are small, localized taxa, the Metrargini being confined to the Hawaiian Islands and Robinsonocorini (not available for study) to the Juan Fernandez Islands.

Conventionally, the subfamily has been characterized by the possession of abdominal spiracles[7] located dorsally on the connexiva, by the presence of a crossvein in the membrane of the hemelytra and by the lack of numerous punctures on the dorsum.

The two major tribes of the subfamily are distinguished by the condition of the apical margin of the corium which is straight in the Lygaeini and inwardly sinuate in the Orsillini. The antennal tubercles also differentiate the groups, being obtuse or subobtuse in the lygaeines and prominently acute or subacute in the orsillines.

From the evidence obtained by study of the male genitalia, it would appear that the Lygaeini and Orsillini are not at all related. The phallus of the Lygaeini (Fig. 9) is characterized by the presence of lateral phallothecal processes, a short, robust conjunctiva, frequently bearing inflatable lobes, but never bearing sclerites, and a vesica that is basally symmetrical. A variably shaped sclerite divides the vesica into two areas, a basal symmetrical one and a distal coiled one. The coiled portion is exceptionally wrinkled, and may bear a pigmented area on its surface. The secondary gonopore may bear an apical process, not found in any other group in the family.

The orsilline phallus (Fig. 2) on the other hand, is characterized by lacking phallothecal processes, by an elongate conjunctiva, without processes, but bearing a ring sclerite just before the distal boundary, and a vesica that is completely asymmetrical. The lobes of the vesica are all unpaired and at least one is always pigmented. There is a strong tendency for reduction of the ejaculatory reservoir in this group. (Figs. 1, 3).

The phallus of the Metrargini, represented here by *Metrarga* (*Nesoclimacias*) *contracta* Blackburn, is unquestionably of the orsilline type, having in common with the orsillines the lack of phallothecal processes and an asymmetrical vesica with one pigmented lobe. The conjunctiva differs in being short and robust and the ring sclerite of the orsillines is replaced by two ventrally located pigmented lobes.

[7]All references to the position of abdominal spiracles are from Hutchinson (1934) and his correction (1945).

Oncopeltus fasciatus (Dallas)

(Figure 9)

Phallotheca.—Heavily pigmented; possessing a pair of lateral, dorsally directed processes, these rounded and free apically.

Endosoma.—Conjunctiva short and robust, bearing a pair of moderately elevated lateral lobes at about the middle, and a single dorsal lobe distally. Ejaculatory reservoir complete, without fusion of parts. Vesica tubular basally; a pair of lateral lobes before middle, extending ventrally; complete ring sclerite at middle, with pointed process forming base of distal area; distal area a somewhat flattened, membranous, finely wrinkled coil, inner surface pigmented, apically narrowing to the seminal duct; gonoporal process relatively uncoiled, of uniform diameter; secondary gonopore flaring, with long apical process present.

Source of Material.—Laboratory culture.

Lygaeus kalmii Stål

Phallotheca.—Strongly pigmented; lateral lobes rounded apically, slightly twisted.

Endosoma.—Conjunctiva short, robust; a pair of dorsal lobes present before distal boundary. Ejaculatory reservoir complete, as in *Oncopeltus fasciatus*. Vesica without processes; basal area short, tightly coiled; ring sclerite complete, narrowly so on one side, greatly widened along the other; remainder of vesica finely wrinkled as in *O. fasciatus*, but irregularly coiled and relatively longer; pigmented area larger and more basally placed; distal area with a groove on outer surface for reception of gonoporal process when phallus is at rest; gonoporal process a little longer than in *O. fasciatus*, obviously covered with an inflatable membrane to its apex; apical process very short

EXPLANATION OF PLATE III

FIG. 16. Phallus of *Emblethis vicarius* Horvath.

FIG. 17. Ejaculatory reservoir and vesica of *Lethaeus cribratissimus* Stål.

FIG. 18. Phallus of *Drymus unus* (Say).

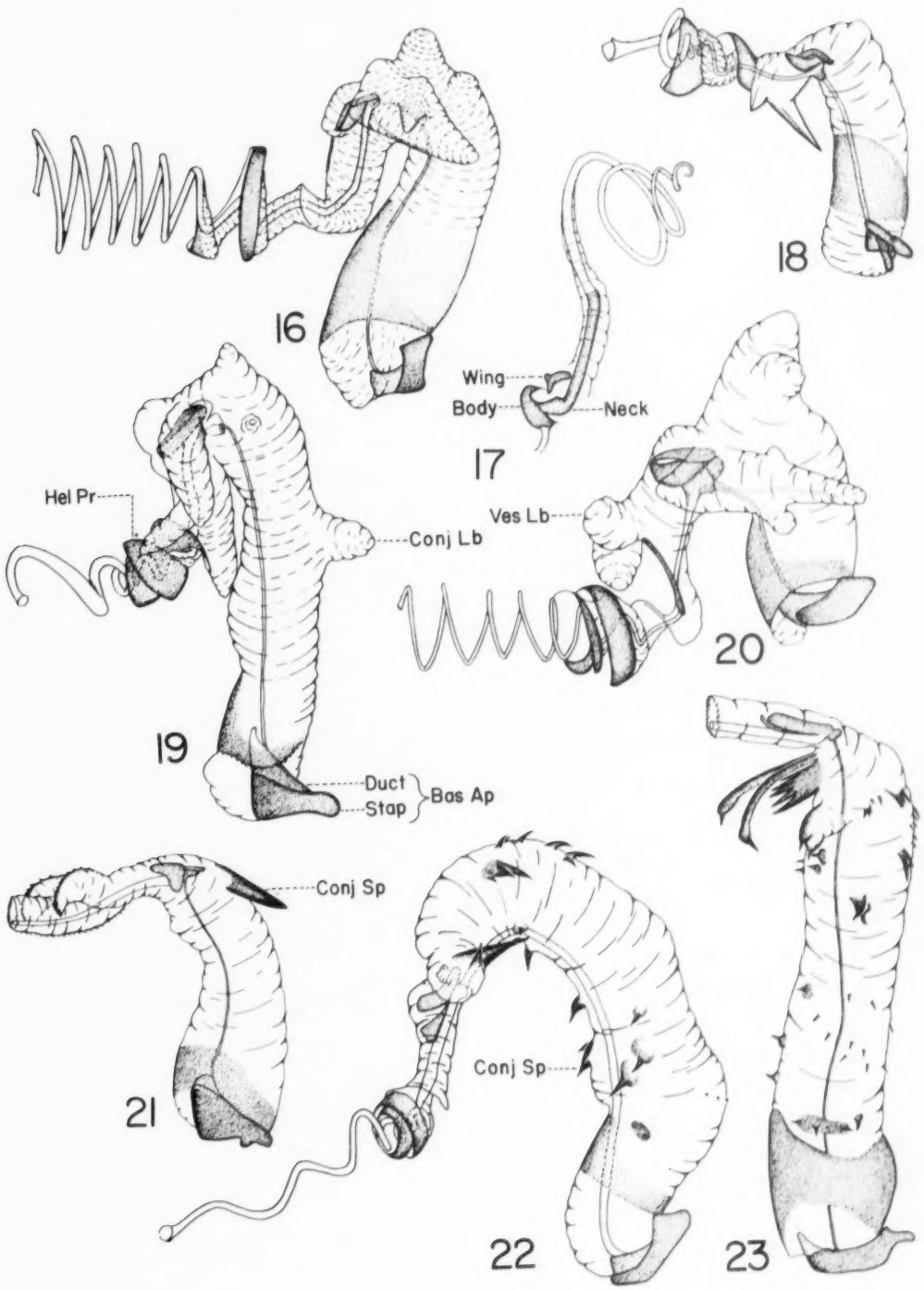
FIG. 19. Phallus of *Myodocha serripes* (Olivier). *Bas Ap*, basal apparatus; *Conj Lb*, conjunctival lobe; *Duct*, ductifer; *Hel Pr*, helicoid process; *Stap*, stapes.

FIG. 20. Phallus of *Beosus maritimus* (Scopoli). *Ves Lb*, vesical lobe.

FIG. 21. Phallus of *Pachybrachius linearis* (Stål), distal portion of vesica deleted. *Conj Sp*, conjunctival spine.

FIG. 22. Phallus of *Ligyrocoris sylvestris* (Linnaeus). *Conj Sp*, conjunctival spine.

FIG. 23. Phallus of *Zeridoneus costalis* Van Duzee, distal portion of vesica deleted.


16
18
Wing
Body
Neck
17
Hel Pr
Conj Lb
Ves Lb
20
19
Duct
Stap
Bas Ap
Conj Sp
21
Conj Sp
22
23

and expanded laterally so that it is wider than long.

Source of Material.—California.

Orsillus depressus Dallas

(Figure 2)

Phallotheca.—Moderately pigmented; without processes.

Endosoma.—Conjunctiva elongate, without processes; a ring sclerite present subdistally; surface finely wrinkled distal to ring sclerite, curving ventrally. Ejaculatory reservoir with body reduced; wings fused dorsally (Fig. 1). Vesica complex, asymmetrical, appearing from base to apex as follows: a single lobe placed dorsolaterally, flattened, directed toward the right and completely pigmented, forming a ring around the vesica; a single lateral lobe directed to the left and dorso-apically; subapical area a flattened round portion, pigmented basally; short narrow tube curved around the flattened area; gonoporal process free and coiled for about one turn (reversed on drawing in order not to cover underparts), of even thickness throughout; secondary gonopore slightly flaring.

Source of Material.—France.

Nysius californicus Stål

Phallotheca.—Moderately pigmented, more heavily so in a definite area along the ventral surface; without processes.

Endosoma.—Conjunctiva shorter than in *Orsillus depressus* and slightly more robust; ring sclerite present before apex; apical portion less wrinkled than in *O. depressus* and not curved as in that species. Ejaculatory reservoir greatly reduced; body lost; neck reduced to a small tubercle; wings appearing as flattened rods buried in membrane of the vesica (Fig. 3). Vesica essentially as in *O. depressus*, but the pigmented lobe more heavily pigmented and with sharp basal boundary; the next lobe (distally) pigmented at the base; the area equivalent to the round, flattened area of *O. depressus* unpigmented, greatly enlarged, curved and elongated; seminal duct ending with inflatable part of vesica, *i.e.*, there is no gonoporal process.

Source of Material.—California.

Metrarga (Nesoclimacias) contracta Blackburn

Phallotheca.—Lightly pigmented; without processes.

Endosoma.—Conjunctiva short, robust, bearing ventral, short, pigmented, paired lobes before distal boundary. Ejaculatory reservoir greatly reduced; neck meeting vesical seminal duct at sharp angle; body reduced to small tubercle on dorsal surface of neck; wings absent; the two components of the seminal duct of about equal thickness so the reservoir has the appearance of a "kink" in the duct. Vesica completely asymmetrical; basal lobe pigmented, the lobe immediately following unpigmented, directed in opposite direction; the tubular area which follows robust, coiled for about one turn, doubling back for one turn; gonoporal process coiled for one turn, completely covered by inflatable membrane; secondary gonopore non-flaring.

Source of Material.—Hawaiian Islands.

Subfamily **Cyminae** Stål 1862

This large subfamily has long been considered to be closely related to the Lygaeinae, differing chiefly by the lack of a crossvein in the membrane of the hemelytra, and by the presence of coarse puncturing on the dorsal surface. The abdominal spiracle pattern differs from that of the Lygaeinae only in that the last pair are located dorsolaterally rather than dorsally.

Two widely distributed tribes are recognized: the Cymini and the Ischnorhynchini. The Cymini are characterized by opaque hemelytra and the presence of a sulcus before the ocelli, while the Ischnorhynchini have hyaline hemelytra and lack the sulcus before the ocelli.

The appearance of the phallic structures indicates that the two tribes differ (in this respect, at least) more from one another than do the lygaeines from the orsillines. Furthermore, some genera currently placed in the Ischnorhynchini (*i.e.*, *Ninus* and its allies) are closely related to the cymines, if at all separable from them. Mr. H. G. Barber is in the process of re-evaluating the groups of the subfamily in connection with his studies of the Micronesian fauna.[6] The genus *Epipolops*, placed in the Geocorinae by Stål (1868), has a primitive cymine phallus and is, therefore, considered here.

The species studied in the Cyminae, together with *Ninus* and its allies, and *Epipolops* sp. have a phallus (Figs. 4, 5, 8) that is characterized by the possession of lateral phallothecal processes, and a pronounced tendency toward a thickening of the vesical seminal duct, unusual flaring of the secondary gonopore and strong reduction of the ejaculatory reservoir. A series of modifications which may well represent a phylogenetic sequence can be ascertained in the four species described below. *Epipolops* sp. (Fig. 4) has a complete ejaculatory reservoir and a moderately thickened, relatively long, loosely coiled and flexible vesical seminal duct. *Ontiscus australicus* Stål also has a complete ejaculatory reservoir, but the vesical seminal duct is greatly thickened, more rigid and shortened. A new South American genus near *Ninus* (Fig. 5) has a greatly reduced ejaculatory reservoir, the neck and body being fused and bearing the wings on the dorsal surface, and the vesical seminal duct is even more shortened than in *O. australicus*. *Cymus angustatus* Stål (Fig. 8) is

[6]Barber (1956) has removed *Ninus* and four related genera to a new tribe Ninini in a paper which appeared since the above was written.

like the *Ninus*-like genus with respect to the vesical seminal duct, but the ejaculatory reservoir is further reduced by virtue of having completely lost the wings.

In surveying the condition of the phallus in other species in this group, it was found that the vesical seminal duct is quite variable between species in its twists and turns, and that the secondary gonopore differs greatly in its degree of flaring. Because the structure, in most cases, is rigid enough to hold its shape when dissected and because it is relatively constant within a species, it is felt that it can be used to great advantage in taxonomic work.

The Ischnorhynchini, as represented by *Kleidocerys franciscanus* (Stål), the type genus (Fig. 6), *Rhiobia chinai* (Esaki) and *Polychisme* sp., are characterized by the lack of phallothecal processes, no conjunctival processes, a symmetrical inflatable basal part of the vesica, and a helicoid process on the apical part. *K. franciscanus* and *R. chinai* are unusual because they are the only forms investigated that have more than two turns to the helicoid process. *R. chinai* is peculiar, in addition, because it presents the only case of a phallus which possesses a helicoid in which there is no free gonoporal process. The secondary gonopore appears at the end of the helicoid process in this species.

Cymus angustatus Stål

(Figure 8)

Phallotheca.—Heavily pigmented; lateral processes slightly pointed and free apically.

Endosoma.—Conjunctiva elongate, without processes. Ejaculatory reservoir greatly reduced; body and neck undifferentiated from vesical seminal duct. Vesica short, with two ventral unpaired lobes, directed slightly laterad from axis; seminal duct greatly thickened, slightly coiled; secondary gonopore strongly flared and apically pointed.

Source of Material.—Connecticut.

New Genus near **Ninus**

Not inflated.

Phallotheca.—Similar to that of *Cymus angustatus*.

Endosoma.—Conjunctiva similar to that of *C. angustatus*. Ejaculatory reservoir somewhat cuboidal in appearance; neck and body fused; wings pointed, directed laterally (Fig. 5). Vesica apparently with paired lateral lobes basally; seminal duct greatly thickened as in *C. angustatus;* secondary gonopore less flaring, and not pointed as in that species (Fig. 5).

Source of Material.—British Guiana.

Epipolops sp.

Not inflated.

Phallotheca.—Very lightly pigmented; lateral processes indistinct and only slightly free.

Endosoma.—Conjunctiva moderately elongate; without processes. Ejaculatory reservoir complete; neck quite narrow; body broadly rounded; wings long and narrow (Fig. 4). Vesica with paired lateral lobes basally and possibly others, not understood; seminal duct greatly thickened, but less so than in *C. angustatus;* secondary gonopore greatly flaring, not pointed (Fig. 4).

Source of Material.—Honduras. This is a species with but one pair of spines produced laterally on the pronotum.

Kleidocerys franciscanus (Stål)

(Figure 6)

Phallotheca.—Moderately pigmented; without processes.

Endosoma.—Conjunctiva moderately elongate, possessing five lobes distally; one dorsal lobe present with pair of smaller lateral lobes at base, and a pair of ventral lobes. Ejaculatory reservoir complete and normal. Vesica tubular for a short distance; two dorsal and one ventral lobes before helicoid process; helicoid process unpigmented, forming about five turns; gonoporal process continuing for about thirteen turns; secondary gonopore non-flaring.

Source of Material.—Utah.

Ontiscus australicus Stål

Not inflated.

Phallotheca.—Well pigmented; lateral processes present, identical with those of *C. angustatus*.

Endosoma.—Conjunctiva elongate, lacking processes, the middle third lightly pigmented. Ejaculatory reservoir complete, as in *Epipolops* sp., but with body rounder, wings shorter and broader, and neck much thicker. Vesica with many lobes, the proximal ones paired, pigmented basally (the other lobes may or may not be symmetrical); vesical seminal duct thickened as in *C. angustatus* but somewhat longer, twisted about three times; inflatable portion of vesica ending at secondary gonopore; secondary gonopore flaring, notched at one side.

Source of Material.—New South Wales, Australia.

Polychisme sp.

Not inflated.

Phallotheca.—Moderately pigmented, more strongly so dorsally to form "sclerite"; without processes.

Endosoma.—Conjunctiva moderately elongate, without processes. Ejaculatory reservoir complete and normal. Vesica with pair of trilobate lobes basally; short tubular area follows with possible apical lobes; helicoid process of one turn unpigmented; gonoporal process exceptionally fine, of about two and one-half turns.

Source of Material.—Chile.

Rhiobia chinai (Esaki)

Not inflated.

Phallotheca.—Moderately pigmented; without processes.

Endosoma.—Conjunctiva moderately elongate; without processes. Ejaculatory reservoir complete; wings long and narrow. Vesica (uniflated) not clear in basal region, possibly with lobes; helicoid process originating close to base and continuing to secondary gonopore, forming three turns, the first turn pigmented, the remainder unpigmented.

Source of Material.—Japan.

Subfamily **Oxycareninae** Stål 1862

This is a small subfamily of predominantly old world species. The phallus (Fig. 7) shows many striking similarities to that of the Lygaeini and might easily be considered to be derived from the phallus of this latter group. The phallotheca bears lateral processes, the vesica has paired lobes in a position similar to that in *Oncopeltus fasciatus*, and these are immediately followed by a ring sclerite as in *O. fasciatus*. In addition, the remainder of the vesica is finely wrinkled in the manner characteristic of the lygaeines. The main difference between the two groups is that the oxycarenines have a more elongate conjunctiva, a complete lack of coiling in the vesica, and a tendency toward reduction of the ejaculatory reservoir.

The oxycarenines have never previously been considered as closely related to the Lygaeinae. One of the major differences between the two is the location of the abdominal spiracles. In the present subfamily the first pair of spiracles is located dorsally but all of the others are placed ventrally.

Oxycarenus hyalinipennis (Costa)

(Figure 7)

Incompletely inflated.

Phallotheca.—Heavily pigmented; lateral processes rounded and free.

Endosoma.—Conjunctiva elongate, without processes; basal third lightly wrinkled; apical two-thirds moderately wrinkled. Ejaculatory reservoir reduced (difficult to interpret); wings apparently absent; body and neck fused, divided distally to give the appearance of wings. Vesica with a pair of short lobes, basally pigmented, directed ventrally; lightly pigmented ring sclerite immediately following; remainder of vesica elongate, uncoiled, finely wrinkled; gonoporal process short, unpigmented, within a membranous tube.

Source of Material.—Laboratory culture, France.

Subfamily **Artheneinae** Stål 1872

This subfamily is composed of a small number of species, predominantly Palearctic in distribution, whose members are somewhat similar in habitus to representatives of the Orsillini and Ischnorhynchini. The phallus of *Artheneis foveolata* Spinola (Fig. 10) is distinctive in many respects. The lateral processes of the phallotheca are exceptionally large and acute, the conjunctiva is unusually short, and the ejaculatory reservoir has undergone a fusion of the body and neck regions.

Despite the identical placement of the abdominal spiracles of this subfamily and the Oxycareninae, the phallic structures do not support close relationship for the two groups. Indeed, the condition of the phallus in the Artheneinae is as dissimilar from the condition found in the Oxycareninae as it is from that present in the Lygaeini and the Cymini.

Artheneis foveolata Spinola

(Figure 10)

Phallotheca.—Moderately pigmented; lateral lobes quite prominent and acute, apex curved medially, percurrent for short distance basally.

Endosoma.—Conjunctiva quite short; with a pair of broad, flat lobes, marginally notched and pigmented, in part lateral to ejaculatory reservoir. Ejaculatory reservoir quite large; body and neck completely fused to form a large, elongate body, rounded basally and tapered apically to the seminal duct; wings broad and flat. Vesica a single, broadly acute lobe, laterally directed to the right; remainder a tubular coil of two turns gradually narrowing to seminal duct; gonoporal process short, continuing for slightly more than one turn; secondary gonopore non-flaring.

Source of Material.—France.

Subfamily **Pamphantinae** Barber and Bruner 1933

This is a small subfamily nearly restricted in distribution to the Antillean Islands. The group is distinguished from others because the first three visible abdominal segments are fused, and no sign of their sutures remains. The abdominal spiracle pattern is that of the Geocorinae, which have the proximal three pairs dorsal and the distal three pairs ventral.

It is possible that the old world subfamily Bledionotinae (Reuter, 1878) may be closely related to this group, but unfortunately no material has been available for study.

Because the phallotheca is very lightly pigmented, it is difficult to decide if the species of *Pamphantus* described below possesses true lateral phallothecal processes, or simple phallothecal sclerites similar to those found in *Hypogeocoris piceus*. A second species, *Pamphantus atrohumeralis* Barber and Bruner, was also investigated, and, though the phallus was even less well expanded, it gave stronger evidence that lateral processes are present. Since no helicoid process is present, it would seem best to consider this subfamily related to the Lygaeini-Cymini line of the family until more material can be studied.

Pamphantus elegantulus Stål
(Figure 12)

Partially inflated.

Phallotheca.—Lightly pigmented; with "sclerite" forming a pattern identical to a lateral process, but not free apically.

Endosoma.—Conjunctiva moderately elongate and robust; without processes. Ejaculatory reservoir complete and normal. Vesica with slightly swollen area present basally; with a pair of elongate lobes extending dorsally; thence a narrow tube coiled for one loose turn; gonoporal process forming a little more than four turns; successively increasing in diameter toward apex; secondary gonopore non-flaring.

Source of Material.—Cuba.

Subfamily **Blissinae** Stål 1862

Important characteristics of the phallus of the blissines (Fig. 14) are the lack of both the lateral phallothecal processes and a vesical helicoid process. In addition, the vesica is proximally symmetrical and distally asymmetrical. *Blissus leucopterus* (Say) has a pair of flat sclerites imbedded in a pair of vesical lobes which become free of the lobes apically, a partially complete vesical ring sclerite, and a long gonoporal process with numerous coils. *Ischnodemus sabuleti* (Fallén) agrees with *B. leucopterus* except that the gonoporal process is very short. *Ischnodemus macer* Van Duzee also has a very short gonoporal process, but differs from both of the above mentioned species in that it lacks sclerites on the vesica.

The only other group that lacks both the lateral phallothecal processes and the helicoid process, other than the diverse pachygronthine-heterogastrine group, is the Orsillini. The tendency toward asymmetry of the vesica may further indicate relationship to this group.

Blissus leucopterus (Say)
(Figure 14)

Partially inflated.

Phallotheca.—Moderately pigmented; without processes.

Endosoma.—Conjunctiva moderately elongate; bearing a pair of short, ventral lobes distally. Ejaculatory reservoir complete; body unusually flattened. Vesica (basal region not inflated) with a pair of robust lobes basally, each with a broad, flattened sclerite becoming free of the lobes distally; a pair of thin rod sclerites dorsally, extending from base of lobe sclerites to base of ring sclerite; ring sclerite narrowly open along dorsal surface, but with narrowly complete area distally, distal margin acute ventrally, extended onto subapical region and deflected to the right, continuing as a thin, pigmented line; subapical region a flattened, rounded area not reflecting the three turns of the seminal duct within it; apically forming a short tubular area before gonoporal process; gonoporal process unpigmented, delicate, and forming about twenty coils; secondary gonopore non-flaring.

Source of Material.—Iowa.

Subfamilies **Pachygronthinae** Stål 1865
and **Heterogastrinae** Stål 1872

These two subfamilies have long been associated with one another and are characterized by having all abdominal spiracles dorsal, hemelytra not wider than abdomen, and enlarged fore femora. The Heterogastrinae are typified by the presence of a crossvein in the membrane of the front wing and by the fore femora being at most sparsely spined. The Pachygronthinae lack the crossvein in the wing membrane and possess many spines on the fore femora.

The inflatable parts of the phallus of these groups are completely contained within the phallotheca when at rest, and it was impossible to inflate them by osmotic pressure. Only one example, *Oedancala dorsalis* (Say) (Fig. 15), of the two subfamilies has been successfully inflated by killing a copulating pair in boiling water. Fortunately for the sake of comparison, Servadei (1951) has figured the phallotheca and inflatable portions of the phallus of *Heterogaster urticae* (Fabricius).

The phallus of both groups is characterized by having the basal apparatus fused with the highly pigmented phallotheca, which is narrow distally and without processes. The conjunctiva is greatly elongated in both subfamilies and is the only part of the phallus that is concerned with holding the phallus within the female organ. This is a unique situation in the family. The ejaculatory reservoir is greatly reduced in both groups. The vesica is also reduced and may have no more than a thin tubular inflatable covering over the vesical seminal duct. *H. urticae* appears to have a proportionately shorter conjunctiva than *O. dorsalis* and the lobes are irregularly placed. In both the drawing of *O. dorsalis* herein and Servadei's figure of *H. urticae* it is doubtful if the vesica is completely drawn out of the conjunctiva.

Singh-Pruthi (1925) noted some of the similarities in the phallus of these two subfamilies and, in addition, noted that members of the Colobathristidae possess a phallus of the same type. There has been discussion by various authors as to the position of the genus *Artemidorus*, some placing the genus in the Colobathristidae and others in the Heterogastrinae. *Artemidorus pressus* Distant was available for study, and it was found that it too was of the pachygronthine-heterogastrine type. Because of this, no conclusions can be reached regarding the evidence from the phallus until a thorough study of fully inflated organs is possible.

Oedancala dorsalis (Say)

(Figure 15)

Phallotheca.—Strongly pigmented, fused with basal apparatus, narrowing apically; without processes.

Endosoma.—Conjunctiva greatly elongated, comprising greater part of phallus; basal half without lobes, of relatively small diameter; middle area somewhat twisted; terminal half somewhat thicker in diameter, bearing a pair of short lobes dorsally beyond middle, a second pair dorsally near apex (these quite long, extending laterally), and a long ventral lobe becoming bifid at apex. Ejaculatory reservoir greatly reduced; body rounded; neck undifferentiated from vesical seminal duct; wings absent. Vesica a short tube (not at all understood).

Source of Material.—Connecticut.

Subfamilies **Henestarinae** Douglas and Scott 1865 and **Geocorinae** Stål 1862

These two subfamilies contain most of the large-eyed and pedunculate-eyed lygaeids. The henestarines are a small group of predominantly Palearctic species, while the geocorines are more numerous in species and are found all over the world.

The two groups have been distinguished primarily by a difference in the position of the abdominal spiracles. The geocorines have the anterior three spiracles located dorsally and the posterior three ventrally, while the henestarines have the anterior and the two posterior spiracles located ventrally.

There is a great deal of similarity between the phallic structures of these two subfamilies, but it is difficult to differentiate them as a group from others with similar structures. Each has unique characters on the vesica, but with the few forms studied, their value is difficult to judge. Thus, it is impossible to decide if the evidence presented by the phallic structures supports the separation of the two subfamilies or suggests a closer relationship than their present grouping would indicate.

The genus *Epipolops* was placed in this subfamily by Stål (1868), but the phallus was found to be of a primitive cymine nature and is treated under that subfamily.

Important characters of the phallus of these two subfamilies (Figs. 11, 13) are that the phallotheca is without processes, but sometimes (*Hypogeocoris piceus* (Say)) bears sclerites that give the appearance of dorsal lobes. The conjunctiva varies from robust to elongate and may have dorsal lobes near the distal end. The ejaculatory reservoir is complete in the species studied. *Henestaris laticeps* (Curtis) and *Hypogeocoris piceus* (Say) have particularly broad wings while those of *Germalus samoanus* China are more narrow and elongate. The vesica may possibly always have paired lobes basally which are followed by a short, tubular area. A helicoid process is always present and is set upon the continuation of the twisted tubular area. In the geocorines studied the helicoid process has a small portion that expands to form a small, flattened lobe (Fig. 11). The helicoid process always has an entire margin in other groups of the family. *Henestaris laticeps* (Fig. 13) has a ring sclerite just beyond the helicoid process. In no other group with a helicoid process has such a sclerite been found to be so placed. The gonoporal process has been found to be variable in length and in degree of coiling, *Henestaris laticeps* having less than one turn, *Germalus samoanus* three, and *Hypogeocoris piceus* more than twenty.

Henestaris laticeps (Curtis)

(Figure 13)

Phallotheca.—Moderately pigmented; without processes.

Endosoma.—Conjunctiva moderate in length, without processes. Ejaculatory reservoir complete and normal; wings broad. Vesica with one pair of lobes basally, inserted dorso-laterally and turned somewhat basally, followed by a short, tubular, tightly coiled area without processes; helicoid process unpigmented, set on a wider tubular coil; ring sclerite at apex on inflatable portion; gonoporal process short, tapered, forming less than one turn; secondary gonopore very slightly flaring.

Source of material.—France.

Hypogeocoris piceus (Say)

(Figure 11)

Phallotheca.—With four paired sclerites, dorsal pair parallelogram-shaped, ventral pair irregularly shaped, extending apically and dorsally nearly to dorsal pair, suggesting lateral processes, but not at all free; remainder very lightly pigmented; without processes.

Endosoma.—Conjunctiva short and robust; a pair of short lobes located dorso-apically. Ejaculatory reservoir complete and normal, but wings unusually broad. Vesica with a pair of long, curved lobes basally, extending ventrally and basally; a short, tubular, coiled area without processes before helicoid process; helicoid process narrow, set on a robust tubular coil, highly pigmented for slightly over one turn, midway with an extended process; gonoporal process coiled for possibly twenty turns or more, increased in diameter at fifth turn, narrowing thereafter and of even diameter.[8]

Source of Material.—Connecticut.

[8]The distal fifteen turns of the gonoporal process were seen during an exploratory dissection. The specimen figured, which was killed in copulation, is missing these coils because they were caught within the spermatheca, and all dried specimens dissected subsequently lacked them. It is suggested that a possible explanation for these lacking coils might be that the gonoporal process may frequently break distal to the thickened fifth coil during copulation.

Germalus samoanus China

Not inflated.

Phallotheca.—Moderately pigmented, heavily so on dorsal surface; without processes.

Endosoma.—Conjunctiva elongate, more so than in *Henestaris laticeps*; no processes detectable. Ejaculatory reservoir complete; wings more elongate than in *Hypogeocoris piceus* and *Henestaris laticeps*. Vesica apparently provided with dorsal lobes basally as in *Henestaris laticeps*, no ventral lobes detectable; more elongate before helicoid process than in *Henestaris laticeps* and *Hypogeocoris piceus*; helicoid process wider than in the other two genera, but with projection as in *Hypogeocoris piceus*; no ring sclerite at apex of inflatable portion; gonoporal process short, forming about three turns.

Source of Material.—W. Samoa.

Subfamilies **Malcinae** Stål 1865 and **Chauliopinae** Breddin 1907

These subfamilies, which are restricted to Africa and to the Oriental region, each contain but a single genus. The two genera have some striking similarities externally, and are therefore treated together. Some of these characters are the presence of scale-like hairs, particularly on the scutellum and the venter, the lobed lateral margins of the abdomen and the short ovipositor. None of these characters appear in other groups of Lygaeidae known to the author. Other less striking characters are the strongly declivent pronotum and head, and the extremely enlarged bucculae.

A very few specimens of *Malcus flavidipes* Stål from the Philippine Islands were available for study and all attempts to expand or stretch out the phallus were unsuccessful. Some structure was observable, but not enough for any concrete conclusions. The phallotheca lacks lateral processes and the ejaculatory reservoir is complete as in *Chauliops fallax* Scott. No sign of the helicoid process is evident, although its presence is not to be excluded as a possibility. Two pairs of sclerites, or sclerotized processes are visible through the phallotheca: one pair is rod-like and originates in the region of the ejaculatory reservoir, and the other pair is similar to the flat vesical sclerites of *Blissus leucopterus*, but is considerably larger, and projects well out of the phallotheca.

The phallus of *Chauliops fallax* Scott was stretched out, but not inflated. It lacks lateral phallothecal processes, and has a well developed helicoid process. It is otherwise without distinctive features.

Whether the phallic structures will indicate a relationship between these two subfamilies or not must wait until more successful studies can be made.

Chauliops fallax Scott

Not inflated.

Phallotheca.—Moderately pigmented; without processes.

Endosoma.—Conjunctiva short, robust; without processes. Ejaculatory reservoir complete; wings and body broad. Vesica with one pair of lobes proximally, and possibly with a second pair also; a short, tubular region following; helicoid process present, forming two turns; secondary gonopore non-flaring.

Source of Material.—Japan.

Subfamily **Rhyparochrominae** Stål 1862

This is by far the largest subfamily of the Lygaeidae and in many ways the most diverse and most poorly known. The group is separated from all others by the nature of the ventral suture between the third and the fourth abdominal segments, which is strongly curved anteriorly and does not reach the lateral margins. The abdominal spiracle pattern is quite variable in this group.

Several tribes were established in this subfamily by Stål (1872–1874), namely, Myodochini, Rhyparochromini, Beosini, Gonianotini, Cleradini, Lethaeini, and Drymini. The last named was combined with the Lethaeini by its author in 1874.

The Cleradini are quite distinctive because of the wide separation of their ocelli and the relatively short first two labial segments. The Lethaeini have the second trichobothria of the fourth abdominal segment closer to the first than to the posterior margin of the segment. Stål's Drymini was separated from the rest of the Lethaeini by possessing two trichobothria on the fourth abdominal segment as opposed to three. The remaining four tribes have two widely separated trichobothria on the fourth segment and are separated primarily by the degree of expansion, if any, of the lateral margins of the pronotum.

In a group as large and diverse as this, the phallus is difficult to characterize. All species (Plate III) lack phallothecal processes, and all except the Lethaeini, but including *Drymus* and related genera, have helicoid processes of one or two turns on the vesica. The gonoporal process is always present and coiled.

Lethaeus and its allies are so peculiar in their phallic structure (Fig. 17) that serious consideration should be given to the resurrection of Stål's tribe, Drymini. The elongate conjunctiva, extremely modified ejaculatory reservoir, with its oddly placed and freely movable wings, the reduced vesica, and complete lack of the helicoid process are the major departures from the normal patterns of the subfamily. Less striking characters are the frequent presence of sclerites on the phallotheca and the usual occurrence of paired lobes lateral to the ejaculatory reservoir.

The presence of three trichobothria on the fourth abdominal segment of *Lethaeus* and its allies, as opposed to two in *Drymus* and its allies, alone should lead one to suspect the polyphyletic nature of the Lethaeini as now understood. There has been some discussion in the past (Bergroth, 1913) about variability in the position and presence of these spots, but they are quite useful in the classification of the North American fauna (Barber, 1918).

Drymus and its allies show a remarkably constant pattern in the various regions of the phallus (Fig. 18). All species investigated possess a short conjunctiva that lacks processes, a complete though variable ejaculatory reservoir, and no paired processes on the vesica. The most conspicuous inflatable process present is a long, pointed, pigmented lobe located basally on the ventral surface of the vesica, which is easily recognizable even in stretched out but uninflated specimens. This lobe is frequently followed by a short, inflatable ridge that may be slightly pigmented. The helicoid process begins at the ridge, continues for two turns and is set upon an inflatable coil. The species examined in this group were *Drymus unus* (Say), *Scolopostethus thomsonii* Reuter, *S. pacificus* Barber, *Gastrodes pacificus* (Provancher), and *Thylochromus nitidulus* Barber. This last species was placed in the Rhyparochromini by Barber (1928), but it clearly belongs to the *Drymus* group both by the structure of the phallus and the position of the trichobothria on the fourth abdominal segment.

The Cleradini, as represented by *Clerada apicicornis* (Signoret), have (next to *Lethaeus* and its allies) the most modified phallus in the subfamily. This is the only species investigated in the family that shows no trace of an ejaculatory reservoir, making it impossible to tell where the conjunctival seminal duct ends and the vesical seminal duct begins. The conjunctiva is short and bears two pigmented dorsal lobes distally and a single dorsal unpigmented lobe just before the vesica (as in *Oncopeltus fasciatus* and *Myodocha serripes*). The vesica lacks paired lobes and has only a single ventral lobe as in *Drymus unus*, but in this species it is unpigmented.

The single ventral lobe suggests the possibility that the Cleradini are related to *Drymus* and its allies. Tribal keys to the subfamily usually begin by removing the Cleradini, before the trichobothria are utilized as discriminatory characters. *Clerada apicicornis*, however, has its posterior fourth abdominal trichobothria near the middle of the segment, only slightly closer to the posterior margin of the segment than it is to the anterior trichobothria, and thus, in a position intermediate between that found in *Drymus* and its allies, and the four tribes described below.

The remaining four tribes, as previously mentioned, are separated from one another by the condition of the lateral margins of the pronotum. In the Myodochini, the pronotum is rounded laterally; in the Rhyparochromini, carinate; in the Beosini, laminately expanded; and in the Gonianotini, laminately expanded laterally with profuse punctures on the laminate area.

With the exception of a number of Myodochini, the phallus of members of these four tribes are but variations on a single pattern (Figs. 16, 19, 20). The conjunctivae are moderately elongate, frequently with variously placed paired or single dorsal lobes. The vesicae always have a pair of lobes lateral to the ejaculatory reservoir, which frequently are pigmented basally or on the inner surface. The remainder may have additional paired or single lobes, and some possess a rod-like sclerite before the helicoid process.

Many Myodochini are unusual by virtue of the possession of dark spines or other sclerotized processes on the conjunctiva (Figs. 21, 22, 23). The shape, position and number of these processes differ greatly between genera and even species.

The simplest spined condition is found in *Paromius longulus* (Dallas) and *Pachybrachius vinctus* (Say) in which there are but two large, dorsal basally directed spines. *Pachybrachius basalis* (Dallas) and *Pachybrachius linearis* (Stål) (Fig. 21) are similar but in addition the vesicae possess lateral lobes with a dorsal row of tiny spines on them. There is also a tendency for asymmetry in these two species. *Ligyrocoris sylvestris* (Linnaeus) (Fig. 22) and *L. diffusus* (Uhler) have a great number of spines distributed in patches on the conjunctiva and are quite similar, but specifically distinct. *Perigenes constrictus* (Say) has only a few patches of spines, but the ventral surface of the conjunctiva subdistally bears a large, sclerotized tubercle that ends in a number of tiny spines. In addition to having a number of spines, including two each on a pair of inflatable lobes, *Zeridoneus costalis* Van Duzee (Fig. 23) bears a pair of sclerotized plates set on edge that end with five spines each and a pair of long, capitate rods each ending with a spine; both structures occur next to each other ventrally at the distal end of the conjunctiva. *Ligyrocoris latimarginatus* Barber is strikingly similar to this species in many respects. It has the same capitate rods, but instead of the two plates ending in spines, there are two rows of five long spines. *Ligyrocoris* (*Neoligyrocoris*) *aurivillianus* (Distant) shows still another pattern of spines. In this species there is a simple band of very tiny spines on the ventral surface of the conjunctiva distally, and the lobes lateral to the ejaculatory reservoir are without spines.

A number of Myodochini investigated completely lack conjunctival spines. These are *Myodocha serripes* Olivier (Fig. 19), *Cnemodus mavortius* (Say), *Heraeus plebejus* Stål, *Pachybrachius bilobatus* (Say), and *Carpilis consimilis* Barber. *C. consimilis* is unusual in that it has thirty-five turns to the gonoporal process, the largest number present in any species investigated.

The various patterns of the conjunctival spines,

and sometimes a lack of spines, may prove to be of great help in clarifying generic concepts in the Myodochini. For example, the evidence given above appears to raise serious question as to the value of the abdominal stridulatory area as a generic character of *Ligyrocoris*. The evidence also indicates a polyphyletic origin of the very large genus *Pachybrachius*.

In the Rhyparochromini, Beosini, Gonianotini, and those Myodochini that lack conjunctival spines, the phallus seems to be of much less value, since all of the phalli appear to be minor variations of a single pattern without obvious tribal differences. When representatives of a larger number of genera have been investigated, useful distinctions may be evident; but, in any case, it is doubtful if phallic characters will be as useful in these groups as they promise to be in those Myodochini that possess spined conjunctivae.

Lethaeus cribratissimus Stål

Not inflated.

Phallotheca.—Highly pigmented; apical margin irregular, extended further on dorsal and ventral surfaces than on lateral surfaces; without processes.

Endosoma.—Conjunctiva quite long; one subdistal dorsal lobe, and two pairs of lobes lateral to the ejaculatory reservoir, one pair short, the other pair longer. (These may prove to be vesical processes upon inflation.) Ejaculatory reservoir highly modified and difficult to homologize with more typical examples; "neck" bent ventrally, "body" basal and ventral to neck, anomalously providing the insertion of conjunctival seminal duct; "wings" lateral and ventral, freely movable about acute tip of body, apparently extending into the longer paired conjuctival lobes (Fig. 17). Vesica short, tubular, without processes, gradually narrowing to seminal duct; seminal duct basally highly pigmented for about one-half the length of the inflatable portion; remainder, including gonoporal process, unpigmented, coiled for almost four turns, each turn distally becoming progressively smaller; secondary gonopore non-flaring (Fig. 17).

Source of Material.—Cyprus.

Drymus unus (Say)

(Figure 18)

Phallotheca.—Without processes; moderately pigmented.

Endosoma.—Conjunctiva short, moderately robust; without lobes. Ejaculatory reservoir complete and normal. Vesica basally with a ventral, short, single, pigmented lobe broadly rounded apically; helicoid process strongly pigmented, set on an inflatable membranous tubular area, forming slightly more than two complete turns; gonoporal process continuing for four turns, gradually increasing in thickness to apex; secondary gonopore slightly flaring.

Source of Material.—Connecticut.

Clerada apicicornis Signoret

Not inflated.

Phallotheca.—Moderately pigmented; without processes.

Endosoma.—Conjunctiva robust; a pair of short, pigmented lobes located dorsally before distal boundary, and a single dorsal lobe distally. Ejaculatory reservoir absent; vesical seminal duct indistinguishable from conjunctival seminal duct. Vesica basally tubular, with a single acute, unpigmented lobe placed ventrally; tubular beyond lobe, narrowing to one-half thickness of basal area, helicoid process forming a little more than one turn; gonoporal process forming seven or eight turns.

Source of Material.—Colombia.

Ligyrocoris sylvestris (Linnaeus)

(Figure 22)

Phallotheca.—Lightly pigmented, more strongly so basally and ventrally; without processes.

Endosoma.—Conjunctiva robust, with many basally directed spines placed from base to apex as follows: a pair of lateral sclerites each with a single minute spine, a row of six minute dorsal spines, laterally paired patches of three spines each, a ventral patch of four spines, a subdistal ventral patch of three spines, and a pair of lateral lobes each with a large and a small spine. Ejaculatory reservoir complete and normal. Vesica basally tubular, without lobes; helicoid process strongly pigmented, forming about two and one-half turns; gonoporal process forming about three turns; secondary gonopore slightly flaring.

Source of Material.—New York.

Pachybrachius linearis (Stål)

(Figure 21)

Phallotheca.—Similar to that of *Ligyrocoris sylvestris*.

Endosoma.—Conjunctiva with two large, subapical, dorsal spines, directed basally, the right one bifid, the left one simple. Ejaculatory reservoir similar to that of *L. sylvestris*. Vesica bearing two lateral lobes directed apically and slightly dorsally, curved ventrally, the left one originating more basad than the right one, each with a dorsal row of minute spines becoming more closely spaced apically, tubular beyond lobes to helicoid process, a row of minute spines below; remainder similar to *L. sylvestris*.

Source of Material.—Paraguay.

Zeridoneus costalis (Van Duzee)

(Figure 23)

Phallotheca.—Similar to that of *L. sylvestris*.

Endosoma.—Conjunctiva with a scattering of spines throughout its length; a pair of lateral lobes

below the apex, each with two spines apically; a pair of subdistal, ventral, flattened processes, each ending in five spines; a pair of distal, ventral, capitate rod-like processes, each with a small spine apically. Ejaculatory reservoir similar to that of *L. sylvestris*. Vesica like that of *L. sylvestris*.

Source of Material.—Connecticut.

Myodocha serripes (Olivier)
(Figure 19)

Phallotheca.—Lightly pigmented, more strongly so ventrally and basally; without processes.

Endosoma.—Conjunctiva moderately elongate; a single dorsal lobe located at about the middle, two small, paired lateral lobes distally, and a single distal dorsal lobe. Ejaculatory reservoir complete and normal. Vesica with basal area tubular, provided with five lobes; paired lobes lateral to ejaculatory reservoir, pigmented basally, and with a short, narrow sclerite at the base, a second smaller pair of lobes directed dorsally and apically, and a single apically directed ventral lobe; helicoid process strongly pigmented, beginning on the ventral single lobe and forming slightly more than two complete turns; gonoporal process continuing for another two turns; increasing in thickness for the first turn and narrowing for the last turn; secondary gonopore slightly flaring.

Source of Material.—Connecticut.

Beosus maritimus (Scopoli)
(Figure 20)

Phallotheca.—Lightly pigmented, more strongly so ventrally and basally; without processes.

Endosoma.—Conjunctiva short and robust; apical dorsal lobe large, with pair of secondary lateral lobes. Ejaculatory reservoir complete and normal. Vesica with pair of elongate, tapered lobes lateral to ejaculatory reservoir, each with pigmented medial line extending from base nearly to apex, and with small secondary dorsal and ventral lobe; a dorsal group of three lobes at end of short tubular area, one directed apically, two laterally and slightly basally; beyond lobes narrowing to helicoid process dorsal rod-like sclerite from base of median dorsal lobe to base of helicoid process; helicoid process basally ridge-like and unpigmented for first turn, normally expanded and strongly pigmented for two turns; gonoporal process five evenly thick turns; secondary gonopore slightly flaring.

Source of Material.—France.

Emblethis vicarius Horvath
(Figure 16)

Phallotheca.—Lightly pigmented, more strongly so ventrally and basally; without processes.

Endosoma.—Conjunctiva moderately short and robust, with pair of short dorsal lobes subdistally and second dorsal pair distally connected by inflatable ridge, slightly longer than subdistal pair. Ejaculatory reservoir complete and normal. Vesica with a pair of long, tapering lobes lateral and slightly basal to ejaculatory reservoir, each with elongate lateral lobe and with medial pigmented bar, ventrally with inflatable connecting ridge; straight tubular area with small dorsal rod-like sclerite follows; tubular area then sharply turning dorsally and coiling slightly; helicoid process beginning on tubular coil and continuing one turn on widened coil, unpigmented for less than one turn, remainder pigmented; gonoporal process five coils of even thickness; secondary gonopore slightly flaring.

Source of Material.—Idaho.

CONCLUSIONS

The phallus of the Lygaeidae is divisible into two basic regions, the phallotheca and the endosoma. Modern authors consider this condition to be common to all Heteroptera. These authors find that the endosoma is further divisible, like those in all members of the Pentatomorpha, into two separate areas, the conjunctiva and the vesica. This study confirms these interpretations.

The phallus of the Lygaeidae is characterized by the possession of a tubular conjunctiva bearing few or no inflatable lobes which, when present, are always short. In all groups of the family, with the exception of the Pachygronthinae and Heterogastrinae, the vesica is inflatable, bears inflatable lobes, and frequently is capable of making a sharp bend ventrally. In these forms the conjunctiva, during copulation, occupies the apical half of the ovipositor and the vesica occupies both the basal half of the ovipositor and the genital chamber. The lobes and the ventral bend of the vesica serve to hold the phallus within the genital tract of the female. In the subfamilies Pachygronthinae and Heterogastrinae, the conjunctiva is greatly elongated and the vesica is very much reduced. In the only species of these two families studied, it was found that, during copulation, the conjunctiva occupied the entire ovipositor and the genital chamber as well. Thus, in these groups the conjunctiva assumes the holding function usually performed by the vesica in the other groups of the family.

One of the objectives of this study was to ascertain the value of phallic characters in the higher category classification of the family. It was found that the phallus varied considerably from group to group and that many useful characters were present, the most important two of which are mutually exclusive. One is the presence of lateral phallothecal processes, and the other is the presence of a vesical helicoid process. Other important characters are the nature and position of conjuctival and vesical processes, the shape and degree of reduction, if any, of the ejaculatory reservoir, the nature of

the vesical seminal duct, the presence of a gonoporal process and the degree of its coiling, and tendencies toward asymmetry of the phallus.

It is feasible to recognize a number of possible phylogenetic lines within the family. The presence of dorsal phallothecal processes relates the Lygaeini, the Cymini, including *Ninus* and its allies, and Oxycareninae, the Artheneinae, and possibly the Pamphantinae. The presence of a vesical helicoid process relates the Rhyparochrominae, the Geocorinae, the Henestarinae, the Ischnorhynchini (less *Ninus* and its allies), the Chauliopinae, and perhaps the Malcinae. The lack of a helicoid process in *Lethaeus* and its allies is probably a secondary loss, since they quite obviously belong to the Rhyparochrominae from their external characters. The Blissinae and Orsillini (including the Metrargini) may form another phylogenetic line since they lack both the lateral phallothecal processes and the vesical helicoid process, and, in addition, show a greater or lesser degree of asymmetry in the vesica. However, conclusions based on what is, for the most part, negative evidence, are quite subject to errors of interpretation. The Pachygronthinae and Heterogastrinae, because of the functionally distinct conjunctiva and greatly reduced vesica, stand well apart from the rest of the family as a separate pyhlogenetic line.

A second objective of the study was to detect characters that might be of value in specific discriminations. These have been found in the vesical seminal duct of the Cymini and in the conjunctival spines, when present, in the Myodochini. On the whole, however, characters at this level have proven to be disappointing, and impractical, even though they undoubtedly will prove to be of great value in relating generic and species groups.

ACKNOWLEDGMENTS

The author wishes to extend his sincere thanks to the following: Dr. James A. Slater of the University of Connecticut, who directed the problem, made many helpful suggestions throughout its progress, and provided many of the specimens used in the study; Dr. Norman T. Davis, also of the University of Connecticut, who assisted with the direction of the problem, and with whom discussion, particularly in regard to morphological questions, was particularly helpful. Equally sincere thanks are due to Dr. Ralph M. Wetzel of the University of Connecticut who critically read the manuscript, and to the following for the gift or loan of specimens which would have been otherwise unavailable: Dr. W. L. Brown, Museum of Comparative Zoology, Harvard University; Mr. T. Hidaka, Kyushu University, Japan; Dr. Earl Raun, Iowa State College; Dr. Robert L. Usinger, University of California, who also read the manuscript; and particularly Dr. Jaques Carayon, Muséum National d'Histoire Naturelle, Paris, France, who provided many European specimens.

REFERENCES CITED

Barber, H. G. 1917. Synoptic keys to the Lygaeidae (Hemiptera) of the United States: Part I. Psyche 24: 128–135.

1918. Synoptic keys to the Lygaeidae (Hemiptera) of the United States: Part II. Psyche 25: 70–88.

1928. Two new Lygaeidae from the western United States. (Hemiptera-Lygaeidae). Bull. Brooklyn Ent. Soc. 23: 264–8.

1956. A new arrangement in the subfamily Cyminae (Hemiptera, Lygaeidae). Proc. Ent. Soc. Washington 58: 282.

Barber, H. G., and **S. C. Bruner.** 1933. A new subfamily of Lygaeidae, including a new genus and two new species of *Pamphantus* Stål. (Hemiptera-Heteroptera: Lygaeidae). Jour. New York Ent. Soc. 41: 531–9.

Bergroth, E. 1913. On some Heteroptera from the Philippine Islands. Ann. Soc. Ent. Belgique 57: 150–4.

Bonhag, P. F., and **J. R. Wick.** 1953. The functional anatomy of the male and female reproductive systems of the milkweed bug, *Oncopeltus fasciatus* (Dallas). Jour. Morph. 93: 177–283.

Breddin, G. 1907. Berytiden und Myodochiden von Ceylon aus der Sammelausbeute von Dr. W. Horn. Deutsche Ent. Ztschr. 1907: 34–47, 203–20.

Dupuis, C. 1955. Les génitalia des Hémiptères Hétéroptères (génitalia externes des deux sexes; voies ectodermiques fémelles). Mém. Mus. Hist. Nat., Paris, (A) (n.s.) 6: 183–278.

Hutchinson, G. E. 1934. Yale North India Expedition. Article VIII. Report on terrestrial families of Hemiptera-Heteroptera. Mem. Connecticut Acad. Arts and Sci. 10: 119–46.

1945. Notes on Hemiptera. Ann. Mag. Nat. Hist. 1944, (11) 11: 769–78.

Kullenberg, B. 1947. Über Morphologie und Funktion der Kopulationsapparats der Capsiden und Nabiden. Zool. Bidr. Uppsala Univ. 24: 217–418.

Leston, D. 1955. The function of the conjunctiva in copulation of a shieldbug, *Piezodorus lituratus* (Fabricius) (Hemiptera, Pentatomidae). Jour. Soc. British Ent. 5: 101–5.

Leston, D., J. G. Pendergrast, and **T. R. E. Southwood.** 1954. Classification of the terrestrial Heteroptera (Geocorisae). Nature, London, 174: 91–92.

Ludwig, W. 1926. Untersuchungen uber den Copulationsapparat der Baumwanzen. Ztschr. Morph. Ökol. Tier. 5: 291–380.

Marks, E. P. 1951. Comparative studies of the male genitalia of Hemiptera. Jour. Kansas Ent. Soc. 24: 134–41.

Michener, C. D. 1944. A comparative study of the appendages of the eighth and ninth abdominal segments of insects. Ann. Ent. Soc. America 37: 336–51.

Piotrowski, F. Badania nad morfologia meskiego aparatu kopulacyjnego pluskwiaków róznoskrzydlych (Hemiptera-Heteroptera) ze szczególnym uwzglednieniem grupy Pentatomoidaria Börner 1934. [Sur la morphologie de l'appareil copulateur mâle des Hémiptères-Hétéroptères, avec considération spéciale du groupe Pentatomoidaria Börner 1934.] Poznań. Tow. Przyj. Nauk, Wydz. mat.-przyr., Prace Kom. biol. [Soc. Amis. Sci. Lettres Poznań, Classe Sci. Math. Nat., Trav. Comm. Biol.] 12(5): 237–74 + iii.

Reuter, O. M. 1878. Note sur une nouvelle espèce d'Hémiptère. Ann. Soc. Ent. France (5)8: 144.

Servadei, A. 1951. Nota sull' *Heterogaster urticae* F. e sul genere *Heterogaster* Schill. (Hemiptera Heteroptera, Myodochidae). Redia 36: 171–220.

Singh-Pruthi, H. 1925. The morphology of the male

genitalia in Rhynchota. Trans. Ent. Soc. London 1925: 127–257.

Slater, J. A. 1955. A revision of the subfamily Pachygronthinae of the world (Hemiptera: Lygaeidae). Philippine Jour. Sci. 84: 1–160.

Slater, J. A., and **H. W. Hurlbutt.** 1957. A comparative study of the metathoracic wing in the family Lygaeidae. Proc. Ent. Soc. Washington. 59: 67–79.

Stal, C. 1862. Synopsis Coreidum et Lygaeidum Suecia. Öfv. Svenska Vet.-Akad. Förh. 19: 203–25.

1868. Hemiptera Fabriciana. 1. Svenska Vet.-Akad. Handl. 7(11): 1–148.

1872. Genera Lygaeidarum Europae. Öfv. Svenska Vet.-Akad. Förh. 29(7): 37–62.

1874. Enumeratio Hemipterorum. 4. Svenska Vet.-Akad. Handl. 12(1): 1–186.

BOOK NOTICES

AMERICAN MOTHS OF THE SUBFAMILY PHYCITINAE, by Carl Heinrich. U. S. National Museum Bull. 207. Pp. viii+581, 1138 figs. 1956.

In this posthumously published revision 194 genera, 619 species and 21 subspecies ("local races") from the New World are recognized as valid. Of these 60 genera, 81 species and 8 subspecies are described as new. A tentative phylogeny of the genera is given in tabular form, based on venation and genitalia. The keys are based on venation for the recognition of the major groups, and then on the palpi, genitalia and other secondary sexual characters. The diagnoses of the species include bibliographic references and concise discussions of the systematics, life histories, economic importance, etc. of each. A check list is given of all recognizable names, and a list of unidentifiable ones.

The systematics of this large and important group of the Pyralididae have always been in very bad condition, so much so that most Lepidopterists had almost given up the attempt to do anything with more than a relatively few species. Since a great many of the names were applied in Europe, many types are lost or unavailable. It has long been apparent that nothing at all could be done without studying the genitalia, especially of types, but often of every specimen. Nothing of the sort had been done by the authors of most of the names or of local lists, distribution records and life history data. Much of the existing literature, in fact, was worse than useless; so that it would have been much easier to simply wipe clean the slate of the past and start afresh. This was, of course, impossible; and none but a few Lepidopterists will ever be able to really appreciate the magnitude of the task that the author of this revision has accomplished.

Fortunately for future workers, the author was extremely careful and conservative in every way. He could have named a great many more species than he did, but only from females with no authentically associated males or host plant data. In the Phycitinae, by the way, disproportionately large numbers of females are often collected. Such things he wisely omitted, realizing that to name them would only produce more of the same old confusion. He also omitted distribution records for which he, himself, had not been able to study specimens. The names of supposed Old World synonyms of which he had not been able to examine the types were also omitted; and no "accepted" synonymy was taken for granted. It took thorough scientific honesty and objectivity to do this. As a result, this monograph is a trustworthy foundation from which future workers with access to more material and additional data will be able to make a comparatively clean start. In generic synonymy and phylogeny, too, the author makes frank confession of the inadequacy of his knowledge. This is as refreshing as cool spring water after the way some writers shuffle genera and species around, not caring how many secondary homonyms they may create, with very little tangible justification.

We now have something to work with in a group of great systematic, ecologic and economic interest. Containing as it does such insects as *Cactoblastis cactorum* (Berg) on the credit side, and many such pests as the Zimmerman pine moth, gooseberry fruit worm, Indian meal moth, tobacco and almond moths and Mediterranean flour moth, the subfamily is of major importance. Undoubtedly a wave of research in the group will now swell, that will add enormously to our knowledge. All future work on these moths will date from this revision, a fitting monument to both the ability and the restraint of its author.

A. B. Klots.

PHYSIOLOGIE DE L'INSECTE, by R. Chauvin. 2nd completely revised edition. Ministére de l'Agriculture, Institut national de la Recherche agronomique. Paris—XVI^e, France. 8°, 917 pp., 103 text figures. 3,500 Fr. (3,800 Fr. postpaid).

This new version of Chauvin's "Insect Physiology" is of interest to all insect physiologists and will be helpful to many others both within and without the entomological profession. The book is rich in information. However, as with the first edition, those who are not directly familiar with the subjects reviewed should read cautiously, for the author tends to lean over backward in order to present, in as few words as possible, all sides of all physiological questions, and thus frequently leaves the reader to pick his way unaided through a morass of apparently conflicting data. Now, not all published observations and hypotheses are of equal validity. He who elects to summarize in public should therefore also accept the obligation of criticism. Chauvin, however, has often neglected this duty, and on occasion his impartiality extends to citing arrant nonsense in the same breath with established fact. *Caveat lector!*

One must grant, of course, that it is no longer possible for one individual to exercise perfect critical judgment in all areas of physiology, and that this is especially true of insect physiology, where even now the actual diversity of functional adaptation is only beginning to draw the attention it deserves. The task of the would-be interpreter is formidable. Observations are scattered, their significance is often obscure and their interrelationships more so, and many pertinent data are not readily accessible. Under the circumstances, Chauvin's mere bringing together of such a welter of fact is an impressive, stimulating, and useful accomplishment. Even the evident incongruity of some of the alleged data he cites without critical comment should serve to provoke reinvestigation and thus to promote eventual understanding of the processes concerned.

With rare exceptions, Chauvin's style is clear and simple, virtues that will be doubly appreciated by the many students whose mother tongue is not French. They will find much to think and wonder about in this book. To the specialist, the volume will be of value

principally as a handy source of original references, and for its exposition of Chauvin's views on fields in which he himself is active.

The present edition follows the same plan as that of 1949, so that there are nine chapters devoted respectively to: I. The Integument; II. Molting and Metamorphosis; III. Digestion and Nutrition; IV. Excretion; V. Circulation—Fat Body—Oenocytes; VI. Respiration; VII. Nervous System—Locomotion. Reflexes and Tropisms; VIII. Sense Organs—Psychic Phenomena; IX. Reproduction—Growth. The text has been extensively rewritten, and enlarged about 50 percent, mainly to accommodate data of more recent vintage than the previous issue. References, including duplications, have been increased from some 2000 to about 2700.

Careless editing has left numerous errors. These are annoying, but few of them are critical.

An alphabetical index lists by genera, families, and common names the insects referred to. Entries under each are in the order of their appearance in the text. There is no subject index as such, but there is a six-page table of contents. A list of references cited, with full titles, is given at the end of each chapter.

It is a pity that a work of this scope and importance could not have had better quality production. The paper is of mediocre grade. Here and there pages are practically illegible because the print shows through so strongly from the reverse. Anyone who opens the book will have to replace the binding at once. One cannot refrain from remarking that this volume was printed under government auspices, and that diversion of a few extra francs from propaganda publications of more questionable value would have eliminated mechanical defects that detract appreciably from the effectiveness of this book.

The preface to the new edition contains some provocative thoughts. Freely translated, they are as follows:

"Before I submit this work to the judgment of research workers, I should like to draw their attention to a problem that I feel important. The proliferation of publications on insect physiology is proceeding at a wild pace and in the most complete disorder. Many data are unusable, for want of being integrated into a whole. Thus, I have been forced deliberately to neglect a great number of facts, for fear of making this book altogether unreadable. The time has come when laboratories must either get together or simply spin in a vacuum. Areas where enough progress has already been made must be pointed out, so that effort may be directed toward problems worthy of further pursuit. Lack of coordination is not conspicuous in the domain of molting and metamorphosis, where all the workers know each other, although there is still room for improvement in their collaboration. But the need for setting matters in order is clear where nutrition, circulation, and especially general biochemistry are concerned; for instance, determinations of the concentration of amino acids in the blood of just any insect are no longer of the slightest interest: what is needed is a comparative study, logically planned and comprising a number of species, none of them chosen at random.

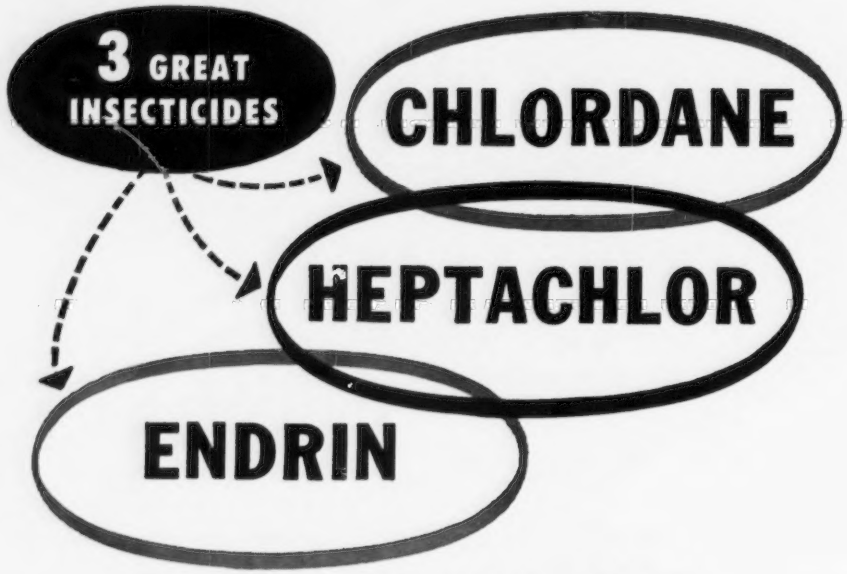
"We also need a more complete international system for bringing papers together, or at least their titles and abstracts; lacking this, even the most thorough bibliographic work does not avoid serious omissions. Only by abolishing the anarchy that characterizes it at present, and by ceasing the accumulation of disconnected data, will we be able to maintain a proper balance in insect physiology. The synthetic chemists have already been forced to discipline themselves, under penalty of perishing otherwise beneath the avalanche of new compounds. I trust that specialists in comparative physiology will imitate them as quickly as possible."

Not all will agree with Chauvin that "abolishing the anarchy" is an essential or even a desirable step toward ultimate progress in insect physiology. However, serious students in the field are well aware that the difficulties on which his proposals focus attention are a growing impediment in many areas of our science. If interest in insect physiology continues to expand at the present rate, some means of circumventing such obstacles will soon have to be found. The problem is how to do so without recourse to the contradiction implicit in the expression "directed research," a solution that is hinted at though perhaps not intended in Chauvin's critique. Possibly one alternative means is the wider dissemination and more attentive reading of such works as Chauvin's "Insect Physiology."

LEIGH E. CHADWICK.

IMPORTANT NOTICE TO AUTHORS

In accordance with action taken by the Editorial Board, each manuscript submitted for publication in the ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA after September 1, 1957, must be accompanied by an abstract prepared in accordance with the requirements of Biological Abstracts, and typewritten (double spaced) *on a separate sheet* (or sheets) of paper. The abstract will replace the usual author's summary. A more detailed announcement of this requirement appears on page 1 in the Bulletin of the Entomological Society of America Vol. 3, June, 1957.



CONTROL THESE INSECTS

CHLORDANE: Ants, Armyworms, Blister Beetles, Boxelder Bug, Brown Dog Tick, Cabbage Maggot, Carpet Beetles, Cattle Lice, Chiggers, Cockroaches, Crickets, Cutworms, Darkling Beetles, Dog Mange, Earwigs, Fleas, Flies, Grasshoppers, Household Spiders, Japanese Beetle Larvae, Lawn Moths, Lygus Bugs, Mole Crickets, Mosquitoes, Onion Maggot, Onion Thrips, Plum Curculio, Sarcoptic Mange, Seed Corn Maggot, Sheep Ked, Silverfish, Sod Webworms, Southern Corn Rootworm, Strawberry Crown Borer, Strawberry Root Weevils, Sweet Clover Weevil, Tarnished Plant Bug, Termites, Ticks, Wasps, White Grubs, Wireworms...and many others.

HEPTACHLOR: Alfalfa Snout Beetle, Alfalfa Weevil, Ants, Argentine Ant, Armyworms, Asiatic Garden Beetle Larvae, Black Vine Weevil, Root Maggots, Clover Root Borer, Colorado Potato Beetle, Corn Rootworms, Cotton Boll Weevil, Cotton Fleahopper, Cotton Thrips, Crickets, Cutworms, Egyptian Alfalfa Weevil, European Chafer, Eye Gnats, False Wireworms, Flea Beetles, Garden Webworm, Grasshoppers, Japanese Beetle, Leaf Miners, Lygus Bugs, Mormon Cricket, Mosquitoes, Narcissus Bulb Fly, Onion Maggot, Onion Thrips, Rapid Plant Bug, Rice Leaf Miner, Salt Marsh Sand Fly, Seed Corn Maggot, Spittlebug, Strawberry Root Weevils, Strawberry Rootworms, Sugar Beet Root Maggot, Sweet Clover Weevil, Tarnished Plant Bug, Tuber Flea Beetle, Western Harvester Ant, White Fringed Beetles, White Grubs (June Beetles), Wireworms ...and many others.

ENDRIN: Budworms, Cabbage Worms, Cotton Boll Weevil, Cotton Bollworm, Cotton Fleahopper, Fall Armyworm, Grasshoppers, Hornworms, Leafworms, Rapid Plant Bug, Spiny Bollworm, Sugar Beet Webworm, Tarnished Plant Bug, Thrips.

WRITE FOR FULL PARTICULARS

VELSICOL CHEMICAL CORPORATION VELSICOL

General Offices and Laboratories
330 East Grand Avenue, Chicago 11, Illinois

Foreign Division
350 Fifth Avenue, New York 1, N. Y.

REPRESENTATIVES IN PRINCIPAL CITIES

PREPUBLICATION ANNOUNCEMENT

Annual Review of Entomology

VOLUME 3

Editor: E. A. STEINHAUS Associate Editor: R. F. SMITH

Editorial Committee: ROBERT GLEN, R. L. METCALF, C. B. PHILIP, H. H. ROSS, E. A. STEINHAUS, C. M. WILLIAMS

Volume 3 of this series will appear about February 1, 1958. Volume 1, which was published in 1956, and Volume 2, which was published in 1957, established the scholastic excellence and up-to-date nature of the ANNUAL REVIEW OF ENTOMOLOGY.

Members of the Entomological Society of America. Your order is to be placed with our Washington office. You will receive an order blank through the mail. It must be returned before December 1, 1957. Member's price is given on the order blank. *Every member should have a copy.*

TABLE OF CONTENTS

Nutrition of Phytophagous Insects ..... W. G. Friend
Physiology of Arthropod Nervous System ..... Kenneth D. Roeder
Chemoreception in Arthropods ..... Edward S. Hodgson
Phylogeny of Insect Orders ..... H. E. Hinton
Zoogeography of Insects ..... L. Gressitt
Internal Anatomy of Insects ..... Philip F. Bonhag
Chemistry and Action of Acaracides ..... Ralph B. March
Organic Phosphorous Insecticides for Control of Field Crop Insects ..... W. A. L. David
Insecticides for Control of Adult Diptera ..... R. W. Fay
Forage Insects and Their Control ..... George G. Gyrisco
Resistance of Plants to Insects ..... R. H. Painter
Ecology of Wild Bees ..... E. Gorton Linsley
Genetics of the Honey Bee ..... Walter C. Rothenbuhler
Biological Control ..... C. P. Clausen
Dynamics of Insect Populations ..... A. J. Nicholson
Mating and Dispersal of Nematocerous Diptera ..... J. A. Downes
Hybridization and Speciation in Mosquitoes ..... Lloyd E. Rozeboom and J. B. Kitzmiller
Success and Failure in Insect Eradication ..... W. L. Popham and David G. Hall
Insect Transmission of Plant Viruses ..... Kenneth M. Smith
Control of Forest Insects ..... R. E. Balch
Uses of Sounds by Insects ..... H. Frings and M. Frings
Internal Symbiotes of Insects ..... A. G. Richards and M. Brooks
Biology of Scarabaeidae ..... Paul O. Ritcher

Libraries, companies, other organizations and non-members should place their orders with: Annual Reviews Inc., Grant Avenue, Palo Alto, Calif. Price to organizations and non-members: $7.00 per copy postpaid in the U.S.A., $7.50 per copy elsewhere.

ENTOMOLOGICAL SOCIETY OF AMERICA

1530 P STREET, N. W. WASHINGTON 5, D. C.

TABLE OF CONTENTS

PAGE

EDMUNDS, GEORGE F., JR., AND RICHARD K. ALLEN—A Checklist of the Ephemeroptera of North America North of Mexico 317

FAIRCHILD, G. B., AND MARSHALL HERTIG—Notes on the *Phlebotomus* of Panama. XIII. The *vexator* Group, with Descriptions of New Species from Panama and California 325

WARD, RONALD A.—A Study of the Host Distribution and Some Relationships of Mallophaga Parasitic on Birds of the Order Tinamiformes. Part 1 335

DRAKE, CARL J., AND JAMES A. SLATER—The Phylogeny and Systematics of the Family Thaumastocoridae (Hemiptera: Heteroptera) 353

SEKHAR, P. S.—Mating, Oviposition, and Discrimination of Hosts by *Aphidius testaceipes* (Cresson) and *Praon aguti* Smith, Primary Parasites of Aphids 370

WILCOX, J., AND CHARLES H. MARTIN—Nannocyrtopogon (Diptera-Asilidae) 376

KRING, JAMES B.—Oviposition Response of *Limonius agonus* (Say) (Coleoptera, Elateridae) to Sand Particle Size 392

JAMNBACK, HUGO, AND ALAN STONE—A First Record of *Simulium* (*Eusimulium*) *congareenarum* (D. & S.) from New York, with Descriptions of the Male, Female, Pupa, and Larva 395

WILSON, H. A., AND C. K. DORSEY—Studies on the Composition and Microbiology of Insect Spittle 399

ASHLOCK, PETER D.—An Investigation of the Taxonomic Value of the Phallus in the Lygaeidae (Hemiptera-Heteroptera) 407

Book Notices 406, 426, 427

Notices to Authors 375, 427

Errata 394